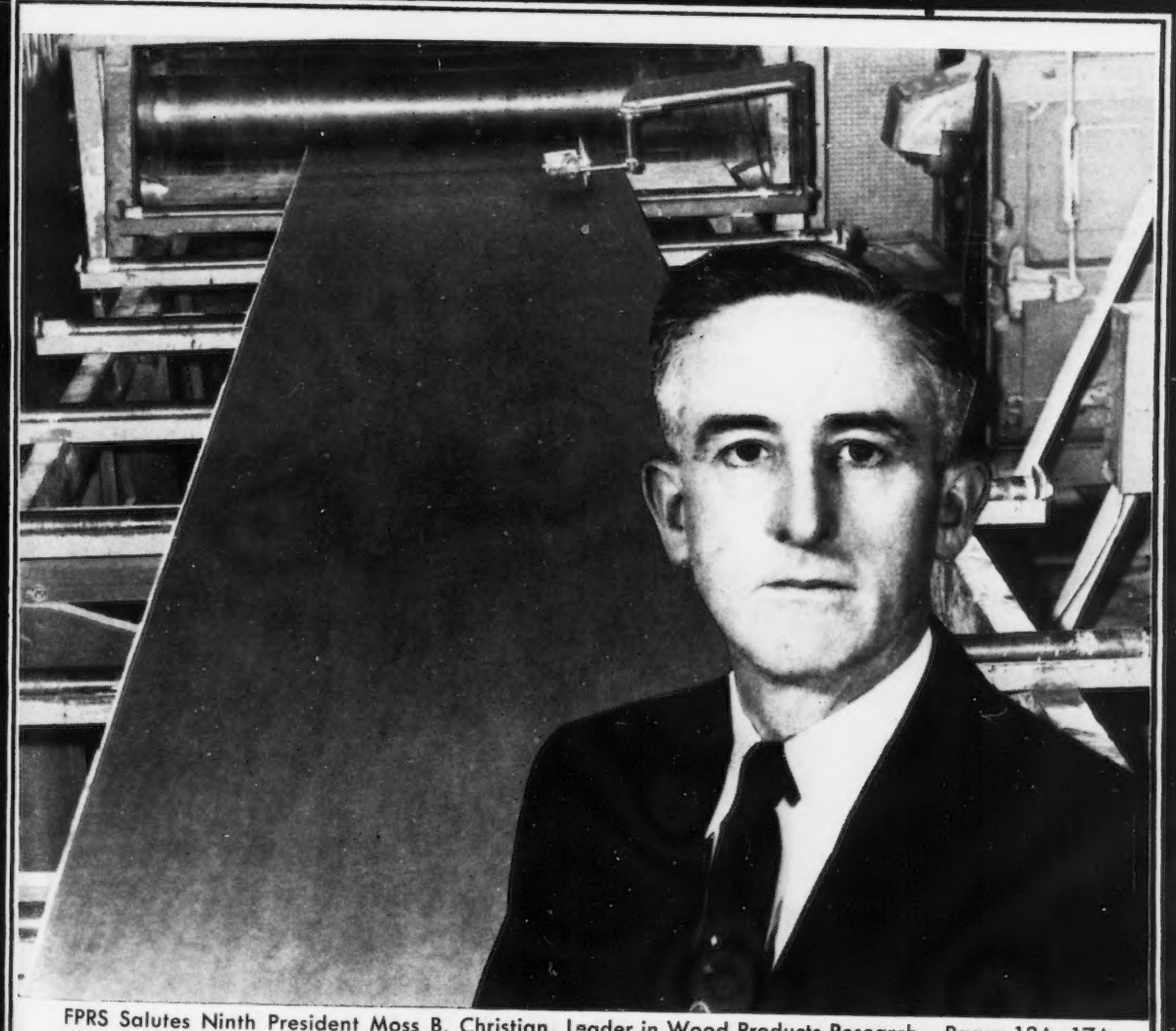
Forest Products Journal



FPRS Salutes Ninth President Moss B. Christian, Leader in Wood Products Research—Pages 13A, 17A

Published by the FOREST PRODUCTS RESEARCH SOCIETY BOX 2010 MADISON 5, WISCONSIN

OMNIBUS OF ADHESIVES

You can choose exactly the right, top-grade adhesive for almost any wood-bonding application from Cyanamid's omnibus of thermosetting resin adhesives. With these adhesives you'll also receive the benefit of technical knowledge, skill and service. Our sales representatives have had practical working experience with all these resins. Their friendly help is at your disposal.

Urac 180 – General purpose, urea-formaldehyde resin in water solution. High-solids solution (66% P.M.M.A. Method) for drum, tank-car or -truck shipments. Catalysts and hardeners are available for all wood-bonding applications – cold or hot press plywood gluing, high-frequency gluing, fortification of starch-dextrine adhesives, etc.

Urac 186 – Similar to Urac 180, but containing 60% resin solids.

Urac 185 – Craze-resistant urea-formaldehyde adhesive for assembly or secondary gluing operations. Two components – liquid resin and powdered hardener. Sets at room temperature with low pressure. Excellent for bonding decorative laminates, Masonite, and other hardboards.

Urac 110 – Similar to Urac 180, but in powder form containing no inert materials. Catalysts are available for general purpose wood gluing – cold or hot setting.

Urac 115 – Powdered urea resin modified to reduce clamping time in room temperature bonding of wood products without addition of highly acidic hardeners. Under special conditions, eliminates use of retaining clamps.

Melurac 300 – Melamine-urea-formaldehyde, one-package, fast-curing colorless powdered resin for hot pressing flat or molded plywood. Combines non-staining, moderate cure temperatures, durability, boil resistance. Ideal for exterior-grade plywood. New catalysts reduce cure rate to that of hot-press urea resins.

Melurac 301 – Powdered melamine-urea-formaldehyde resin without filler.

Melurac 255 – Powdered melamine-urea-formaldehyde resin, two-package, formulated solely as an adhesive for tapeless splicing of veneers.

Melurac 259 – Newly-developed, one-package melamine-urea-formaldehyde resin for tapeless splicing of veneers, requiring addition only of water.

Melmac 401 – Hot press melamine-formaldehyde plywood adhesive for use with or without fillers. May be added to urea resins to improve durability of bond. Also used for laminating heavy timbers in marine applications and for general purpose work where a boil-resistant, non-staining bonding agent is required.

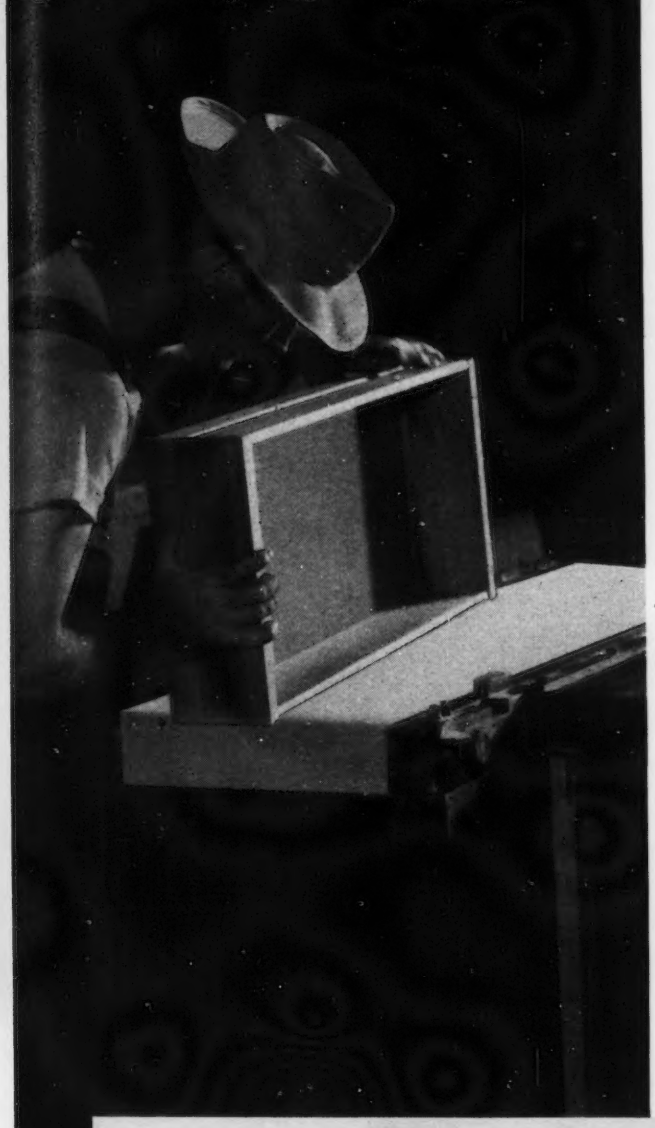
Melmac 405 – A powdered melamine-formaldehyde resin formulated especially for the production of high-pressure, hot-setting laminates of glass cloth, asbestos, canvas, paper, or fine wood veneers.

PDL-1-1969 and PDL-1-1970 – Two resins recently developed especially for use as wood waste binders. Fine, free-flowing powders that are easily handled. Water-white when fused, impart no color to the wood waste board. Can be blended dry or sprayed from water dispersion into wood chips or sawdust.

The trade-marks Urac, Melurac and Melmac are Reg. U.S. Patent Office

In Canada: North American Cyanamid Limited, Toronto & Montreal

You can spot productive hands by the company they keep!



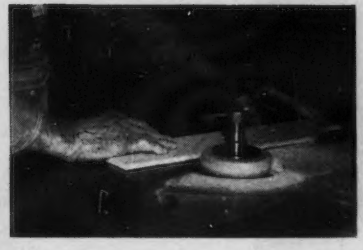
Drawer sanding gets a lift with Behr-Manning abrasive belts

The job is fast and easy with this up-to-date coated abrasive application. A wide BEHR-MANNING abrasive belt, cool cutting and long-lasting, teams with a glass-lipped drawer sander to assure superior finishes at record breaking speed.

Whatever your finishing problems, a BEHR-MANNING Field Engineer can be helpful. He'll recommend a solution and prove it in your plant or at a BEHR-MANNING Demonstration Room. Write Behr-Manning, Troy, N. Y., Dept. FP-6.

In Canada: Behr-Manning (Canada) Ltd., Brantford.
For Export: Norton Behr-Manning Overseas Inc., New Rochelle, N. Y., U. S. A.

W-2



Delappe Discs are tops for smoothing contoured edges.

Behr-cat Strapping Tape holds tight without damaging wood surfaces.

India and Hard Arkansas Oilstones for clean, sharp cutting edges.

BEHR-MANNING division of NORTON Company

▲ COATED ABRASIVES ▲ SHARPENING STONES ▲ PRESSURE-SENSITIVE TAPES

The bond that helped build a thriving industry!

• From a few panels of "veneer" exhibited by an obscure Oregon basketmaker in 1905 . . . to over 4 billion square feet of fir plywood projected for 1955! That's what you call remarkable growth.

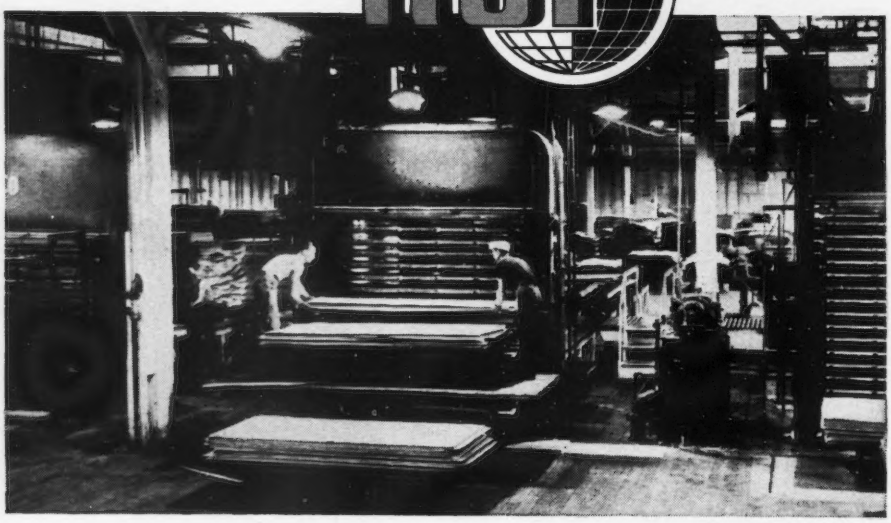
This achievement could not have been realized were it not for the "bond" between the plywood industry and major resin adhesive producers . . . typified by Reichhold Chemicals. RCI resin glues under the "hot press" and RCI's standard of service to the plywood industry are *both* examples of the bond that has helped create the amazing strength of a product . . . and an industry!

Reichhold salutes the Douglas Fir Plywood Association on its first fifty years. In the next half century, we look forward to continuing our work with you . . . developing new adhesives to make plywood even more versatile . . . supplying your ever growing needs for a wide range of first quality resin glues.

FIR PLYWOOD
1905 1955
Cross-bonded Panels of Real Wood Large. Light. Strong
GOLDEN JUBILEE

RCI

Creative Chemistry . . . Your Partner in Progress



REICHHOLD

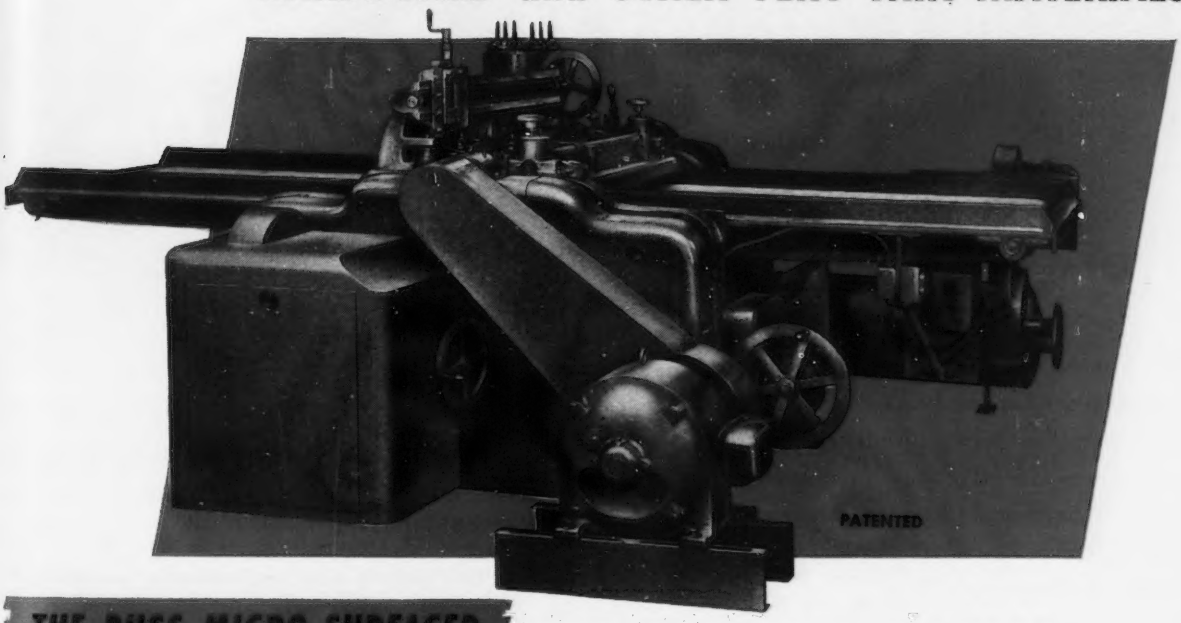
Synthetic Resins • Chemical Colors • Industrial Adhesives • Plasticizers
Phenol • Formaldehyde • Glycerine • Phthalic Anhydride
Maleic Anhydride • Sodium Sulfite • Pentaerythritol • Pentachlorophenol

REICHHOLD CHEMICALS, INC., RCI BUILDING, WHITE PLAINS, N. Y.

BUSS

The MICRO-SURFACER

A HIGH PRODUCTION MACHINE for PLANING HARDBOARD and OTHER VERY THIN MATERIALS!



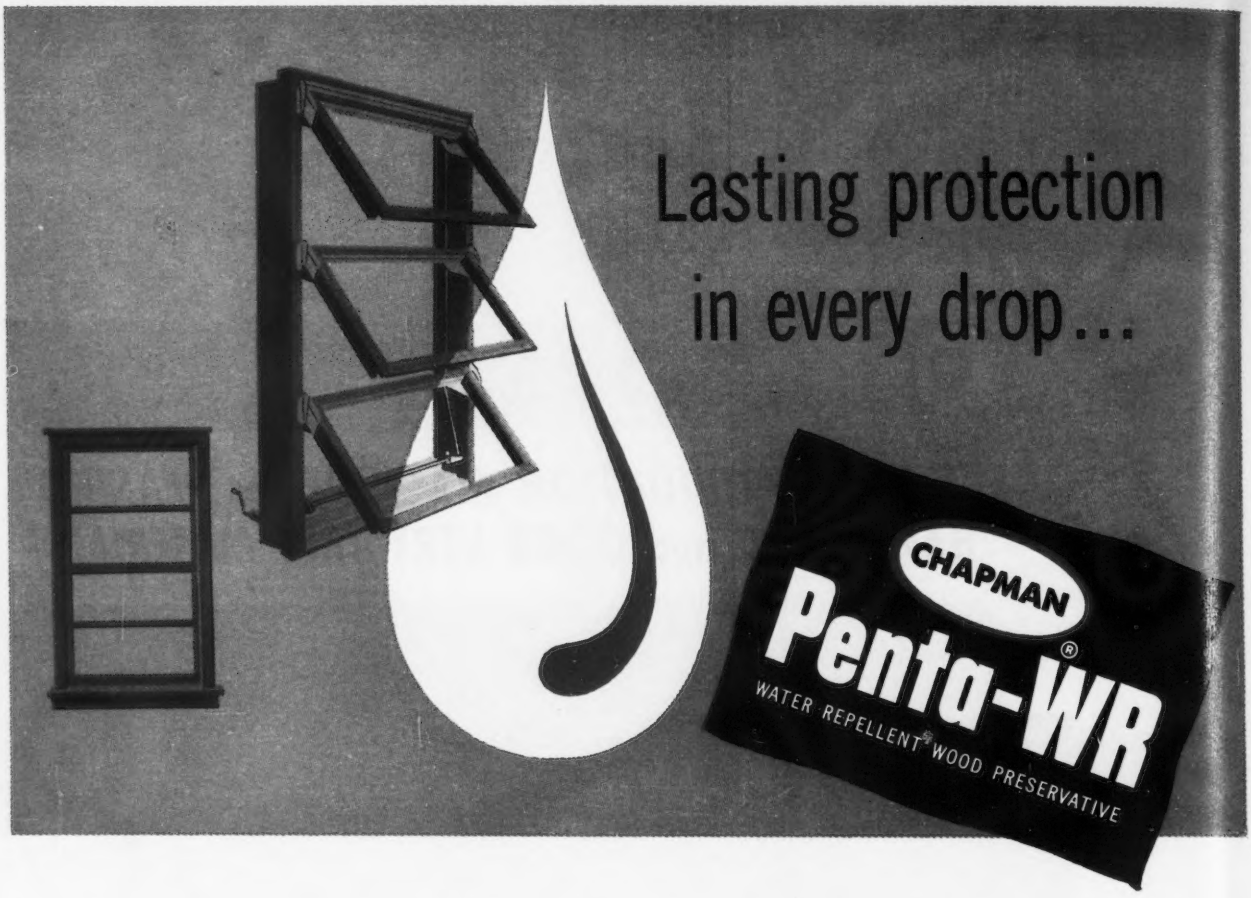
THE BUSS MICRO-SURFACER was developed to do what no other planer will do satisfactorily — to plane the very thin, highly flexible materials such as certain types of hardboard, presswood and related materials, rapidly and accurately. Close tolerances are easily maintained on this machine by means of a patented work platen which rigidly holds down the stock during the feeding and cutting operation. It employs our standard planer cutterhead with high speed steel knives operating at speeds up to 5,000 RPM. (Carboloy knives are available for applications involving abrasive materials). The MICRO-SURFACER can be furnished with in-feed and out-feed conveyors for rapid handling of stock and incorporates such exclusive BUSS features as: Chrome-plated wearing surfaces, semi-automatic control of lower rolls and pressure bar, one-shot lubrication, etc. Available in various width capacities up to 50".

The services of our engineering staff are available for consultation and working out details of all planer applications. Complete cooperation will be extended in any prospective application such as profile and contour work. Drop us a line.

BUSS
MACHINE WORKS
SINCE 1862

PLANER SPECIALISTS

292 EIGHTH AVE., HOLLAND, MICH.



■ There's positive, long-lasting protection for millwork in every drop of Chapman Penta-WR. This clean, paintable, water repellent preservative is carefully formulated for maximum effectiveness. Production is quality-controlled in the modern Chapman laboratory and plant. Users of Chapman Penta-WR may also benefit by these additional Chapman services:

1. You can buy for maximum economy—Fast delivery in tank cars, tank transports or drums (Carloads or LCL) from warehouse stocks throughout the U.S. Also available in Canada.

2. Your choice of concentrates or ready-to-use solution—Chapman Penta-WR is produced in concentrates of 1-to-5 and 1-to-3 and a ready-to-use solution.

3. You can obtain free engineering assistance—On request, Chapman Chemical Company will provide free engineering designs and specifications for setting up your own millwork treating system.

CHAPMAN® **PENTA-WR**

Pentachlorophenol • Water Repellent Preservative • Meets Federal Specifications TT-W-572 and MIL-P-906B

Write for information and prices

CHAPMAN CHEMICAL COMPANY
Dermon Building—Memphis 3, Tennessee

LIC. NO. WATER REPELLENT PRESERVATIVE APPROVED NATL. WOODWORK MFRS. ASSN.

Modern occasional furniture made by the Kaufman Furniture Co., Collingwood, Ontario, combines the lasting protection of plastic surface with the quality of skilled craftsmanship. WOOD-LOK, National's cold run, ready-for-use resin glue, is used for a variety of the laminating and gluing operations.

modern methods...with Wood-Lok

STRONGER GLUING

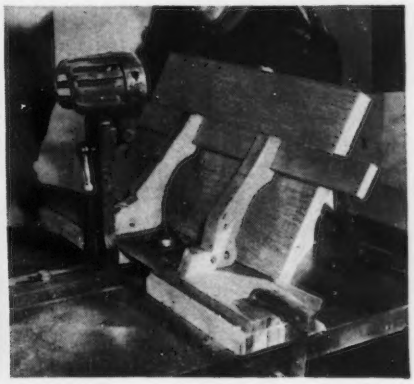
WOOD-LOK dowel joints are the strongest possible type, as proved by an independent three year accelerated aging test. In dowelling, an open assembly time of 5-7 minutes prevents chilled joints. No heating is necessary.

SIMPLIFIED LAMINATING

WOOD-LOK securely laminates plastic or pressed board in only 20-30 minutes. Presses can be emptied in time for reloading without bar clamping and handling of heavy clamped up stacks. The process is simple and continuous.

FASTER MACHINING

WOOD-LOK produces handling bonds in 20-30 minutes press time and reaches machining strength ONE hour later. Machining is continuous, without the delay of long curing times. Auxiliary jig is adjustable for varied operations.



RESYNS® National ADHESIVES

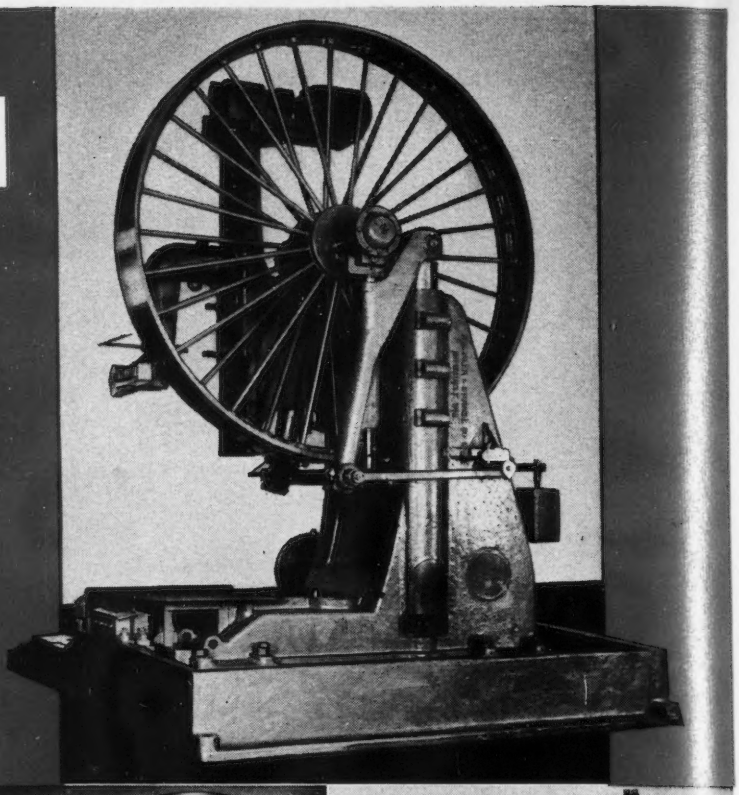
SPECIAL OFFER! Write for 5 gallons of WOOD-LOK and a complimentary glue applicator—on a trial and approval basis.

NATIONAL ADHESIVES. Woodworking Department FP (Resin Division) 270 Madison Ave., New York 16 • 3641 So. Washtenaw Ave., Chicago 32 • 735 Battery St., San Francisco 11 • 1511-23 So. Main St., High Point, N. C.

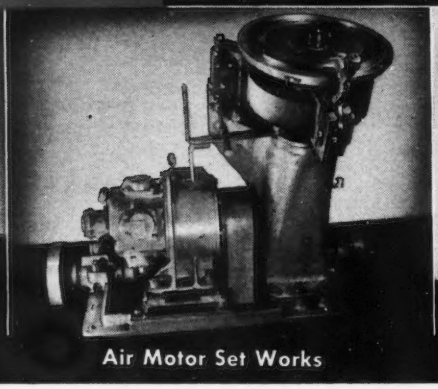
Filer & Stowell

World's largest builders of Heavy Duty Sawmill Machinery

Since 1856



Air Dog Carriage



Air Motor Set Works

Air Dog Knee

PROVEN IN SERVICE

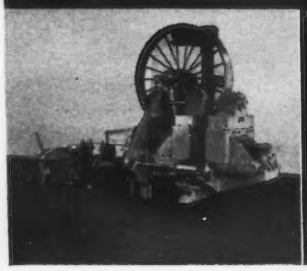
For 98 years the name Filer and Stowell has been associated with the finest in sawmill machinery. Years of manufacturing experience and engineering progress in all types of lumber operations have resulted in our complete line of machinery designed to meet the needs of the industry.

Many outstanding features of construction have set the pace under the toughest conditions with increased production efficiency, reduced maintenance costs and greater profits to you.

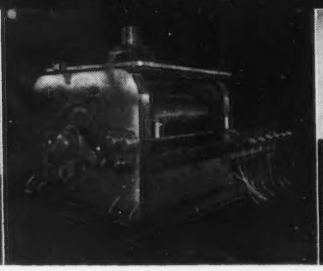
Take advantage of our facilities. Write or wire for complete details on the finest precision-made sawmill machinery available.

THE FILER AND STOWELL COMPANY
149 East Beecher Street • Milwaukee 7, Wisconsin

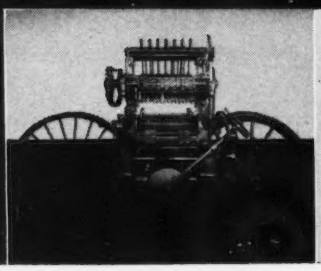
Vertical Band Resaw



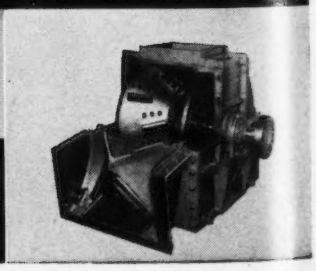
Heavy Duty Edger



Horizontal Resaw



Roller Bearing Hog



FPRS

Executive Officers

President
L. J. Carr, Sacramento, Calif.

President-Elect
M. B. Christian, Tallulah, La.

Vice President
R. H. Bescher, Pittsburgh, Pa.

Past President
R. D. Pauley, Tacoma, Wash.

Executive Secretary
Frank J. Rovsek, Madison, Wis.

•

Regional Board Members

Southeast
E. S. Harrar, Durham, N. C.

South-Central
W. J. Eason, Memphis, Tenn.

Northeast
F. T. Parrish, Gardner, Mass.

North-Central
J. Alfred Hall, Madison, Wis.

Northwest
J. D. Ritchie, Tacoma, Wash.

Southwest
R. E. Shreck, San Francisco, Calif.

•

Publications Committee

Chairman
Edward G. Locke, Madison, Wis.

•

Editorial Staff

Editor
Edward H. Roche, Madison, Wis.

THE FOREST PRODUCTS JOURNAL is published in February, April, June, August, October and December by the Forest Products Research Society, P. O. Box 2010, University Station, Madison 5, Wisconsin. Entered as Second-Class Matter, April 1952 at the Post Office, at Madison, Wisconsin.

Annual subscription rate, $15.00; single copies $2.00, except October Yearbook Number, $5.00. Annual subscription rate is $11.25 with voting, associate, and supporting memberships in the Society. Remittances should be made payable to the Forest Products Research Society.

Correspondence on editorial matters should be addressed to the Editor, at the Executive Office. The Society is not responsible for views expressed in publications.

FOREST PRODUCTS JOURNAL

Vol. V, No. 3 June, 1955

CONTENTS

Page

FPRS News-Digest ---- 11A, 48A
FPRS Ninth National Meeting Host to Hundreds at Seattle, June 21–24 ---- 13A
Official Technical Program, Ninth National Meeting ---- 14A
National Meeting Timetable of Events ---- 15A
Paul Bunyan Potlatch Highlights Social Events at National Meeting ---- 19A
Meet the Authors and Chairmen for the Ninth National Meeting ---- 20A
President's Column—Challenges in the Years Ahead ---- Lester J. Carr 29A
Guest Editorial—Five Tools for Progress ---- J. H. Jenkins 31A

UTILIZATION

Fiber Products as a Factor in Utilization ---- E. G. Locke and K. G. Johnson 153
Tests of a Portable Wood Chipper ---- J. L. Arend, R. N. Smith, and R. A. Ralston 156
The Economic Importance of Wood Residue in the South ---- W. R. Smith 33A
By-Products from the Redwood Lumber Industry ---- R. W. Miller 35A
Converting a Steam Plant from Coal to Hog Fuel Burning ---- W. H. Rambo 37A

WOOD PRESERVATION

New Uses for Wood ---- R. H. Mann 161

MILLWORK

Decay in Exterior Millwork ---- R. M. Lindgren 163
The Use of Small Cuttings in Manufacturing Millwork ---- W. A. Norman 39A

FURNITURE MANUFACTURE

Increasing Lumber Yields with a Patched Strip Core ---- J. S. Bethel and W. B. Woodrum 165

GLUES AND GLUING

Adhesives in Glued-Laminated Timber Construction ---- N. F. Smith 168
Wood and Metal Combinations ---- P. H. McCormack 174
Gluing Hardboard to Fir Plywood with Phenolic Resin Adhesives ---- A. L. Lambuth 177

LUMBER MANUFACTURE

Milling Applied to the Modern Distribution Yard ---- M. A. Sellner 179
Cost Control in Lumber Manufacturing ---- F. L. Muncy 182
Sawing Wood with Circular Headsaws ---- G. W. Andrews 186
Design and Planning of a Montana Sawmill ---- E. C. Wert 40A

FINISHES

Swelling of Paint Films in Water, V: Effects of Different Pigments ---- F. L. Browne 192

SEASONING

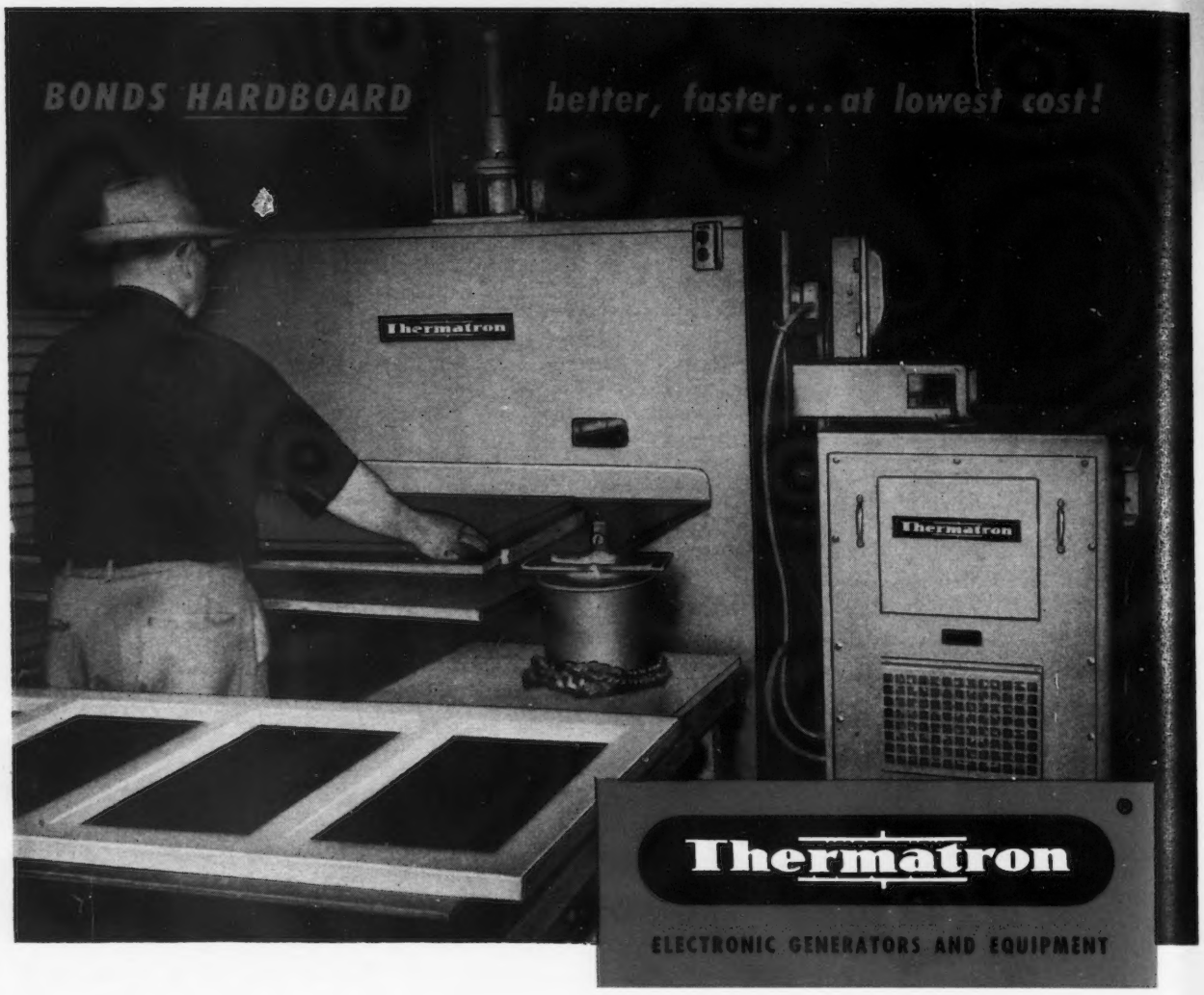
Losses Incurred in Drying and Dressing Lumber in the Southern Interior of British Columbia ---- C. F. McBride 200
A New Direct Heat Exchanger for Kiln Drying Lumber ---- Peter Field 204

RESEARCH AND EDUCATION

Forest Products Research and Education at Michigan State College ---- H. J. Raphael and J. W. Goff 206

DEPARTMENTS

FPRS Company Supporting Members ---- 30A
Around the World in Forest Products Research ---- Edited by G. M. Hunt
Swedish Homes in Parcels ---- Lennart Bergvall 42A
Book Review—Yield Study in the German Plywood Industry ---- Reviewed by H. O. Fleischer 44A
Abstracts from Current World Literature ---- 45A
Wood Drying Committee Newsletter ---- 47A
Index to Advertisers ---- 56A



Tempered hardboard can be successfully bonded with THERMATRON electronic generators and hydraulic presses — combining the best, fastest and most inexpensive method of gluing with the best and cheapest wood-material on the market today! The variety of products is practically limitless with new uses being discovered daily . . . from radio and TV cabinets, furniture and displays *to houses and even vehicles!*

If you're fabricating tempered hardboard or planning to do so let us show how the THERMATRON way of bonding can benefit your production. We'll offer suggestions and application engineering without obligation. Write us today for complete details and ask us for our instructive bulletin no. FP-5.

IN RADIO AND ELECTRONICS SINCE 1922

Thermatron *Division*

RADIO RECEPTOR COMPANY, INC.

SALES DEPARTMENT: 251 WEST 19th STREET, NEW YORK 11, WAtkins 4-3633
Chicago Sales: 2753 West North Avenue *Factories in Brooklyn, N.Y.*

Siempelkamp

HIGH CAPACITY

VENEER DRYER...

Numerous exclusive design features make Siempelkamp roller type veneer dryers outstanding performers under any conditions. They are manufactured by G. Siempelkamp & Co., Krefeld Germany—the world's oldest and largest manufacturer of hydraulic presses for the woodworking industry. Complete U. S. service is available for both presses and veneer dryers.

WILCO Machine Works

For full information, write or telephone

WILCO MACHINE WORKS

1301 N. Hollywood MEMPHIS 8, TENN. Tel. 4–1188

YOUR GUIDE TO *Better* ADHESIVES . . .

The Perkins Trade Mark is your guarantee of quality and reliability when you purchase glues. Since 1899, customer-confidence in Perkins has grown steadily—a deserved tribute to superior products backed by competent service and rigid ethical standards. When you use a Perkins Glue in your operations, you'll agree with other leading woodworkers—*that Perkins serves you best!*

GLUING PROBLEMS?

Dispose of them by calling upon the skilled assistance of the Perkins Technical Service Department. Specialists in gluing methods will study your particular operations and offer suggestions where pertinent. There is no cost or obligation involved in your use of this unbiased advice.

IT'S A PERKINS SERVICE!

RESIN—Hot Press and Cold Press • Liquid or Powder Type
CASEIN—A broad line to meet your specific requirement
VEGETABLE—As originated and perfected by Perkins Glue Co.
ANIMAL—Ready-to-use Liquid • Heat-then-use Gel

• • •

VENEER AND CORE REPAIR COMPOUNDS • VENEER SIZE
GLUE ROOM SPECIALTIES • MIXERS • SPREADERS • BRUSHES

RESIN
CASEIN

PERKINS

VEGETABLE
GLUES

ESTABLISHED 1899

LANSDALE, PA. KITCHENER, ONT.

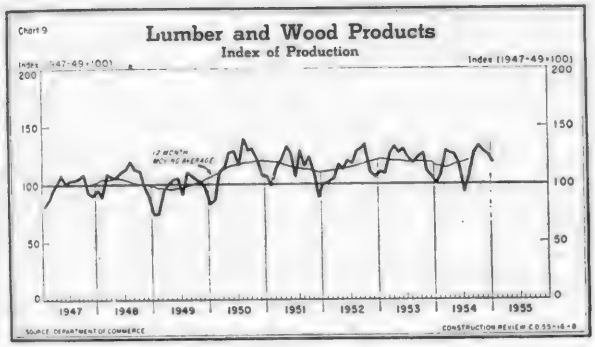
FPRS NEWS-DIGEST

Volume 5 JUNE, 1955 Number 6

BUSINESS OUTLOOK

PLYWOOD BOOM IS CONTINUING with back orders piling up at record rate. Mills, working overtime, boosted early '55 production nearly 25 per cent over last year. Industry has set production goal of 4.4 billion square feet this year, is going all-out for new markets. Output has been increasing at rapid pace in post-war period; more than doubled in past five years. New construction uses account for about 50 per cent of present production, industrial uses 20 per cent, and building remodeling and repair 15 per cent.

GRAPHIC TRENDS

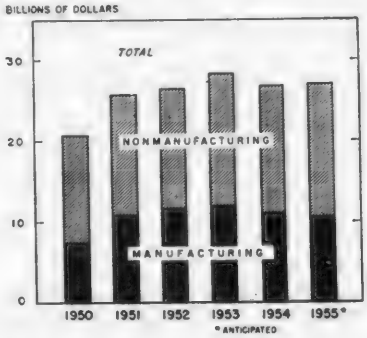


—CONSTRUCTION MATERIALS INDEXES OF OUTPUT, 1947-54

1947-49 monthly average = 100

Year	Annual average	Jan.	Feb.	Mar	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.
LUMBER AND WOOD PRODUCTS													
1947	98.1	81.8	87.4	95.4	100.4	108.2	101.1	103.5	104.6	104.1	108.6	94.2	90.5
1948	104.0	95.8	89.2	108.2	105.5	105.8	110.1	112.1	110.2	112.4	111.0	100.0	90.8
1949	96.0	73.4	73.5	94.1	99.5	104.1	105.6	90.6	110.7	107.6	104.0	102.9	97.1
1950	115.2	82.9	86.4	110.9	115.1	127.6	128.4	116.3	130.9	120.6	130.4	119.7	107.0
1951	114.2	100.6	98.3	114.5	121.2	133.6	126.7	106.7	125.0	115.1	122.3	107.0	88.6
1952	115.0	100.8	101.4	104.6	116.5	112.6	119.5	110.9	127.9	130.8	134.0	109.8	105.2
1953	120.1	110.4	108.6	125.0	142.1	126.4	130.1	122.3	118.8	122.8	126.6	111.3	106.0
1954	118.3	102.1	107.1	128.1	126.3	124.5	117.8	94.9	107.6	126.6	133.5	127.5	124.0
MILLWORK													
1947	96.0	95.4	85.4	91.4	98.9	101.0	98.7	99.0	96.6	91.2	112.6	101.9	100.2
1948	105.1	112.8	108.5	121.0	118.3	107.5	102.1	89.4	111.8	117.1	107.8	96.4	104.9
1949	95.8	91.5	89.2	103.7	87.1	84.8	92.5	68.1	100.7	104.3	105.2	113.4	108.5
1950	122.8	105.7	109.5	136.7	127.4	131.0	130.1	95.8	139.6	120.4	133.0	129.8	114.4
1951	95.9	128.7	113.8	127.2	114.7	113.9	90.5	65.5	84.9	73.4	91.9	77.3	68.5
1952	94.2	78.2	81.0	85.7	91.6	88.1	99.0	89.5	102.1	107.2	114.5	92.3	101.3
1953	93.7	108.0	107.9	113.6	101.1	97.2	89.2	82.6	80.8	92.2	90.4	76.8	75.9
1954	97.2	75.9	83.3	97.4	91.9	91.5	98.5	110.6	102.9	120.2	121.6	108.8	114.4

YEARLY BUSINESS INVESTMENT IN PLANT AND EQUIPMENT



TWO RECORD HIGHS were set by new construction activity in March. Seasonal expansion brought value of new construction put in place to new high for the month ($2.9 billion) and for first quarter ($8.4 billion). The January-March '55 figure topped last year's first quarter record by 13 per cent. Construction activity in first three months this year was at unprecedented annual rate of $41 billion, compared with actual total outlay of $37.2 billion in 1954. Construction materials output in January was higher than same '54 month, with softwood lumber production up 10 per cent and hardwood flooring increased 20 per cent. The wholesale price index for building materials, rising slowly since last summer, edged up again in February. At 122.5, it was 3.4 per cent above '54 low in June.

—Construction Review

INCREASED MOMENTUM IN FURNITURE INDUSTRY ties in with record-breaking house building activity, Seidman & Seidman report. Furniture activity first two months of '55 extended rise in fourth quarter of '54. New orders booked by reporting plants in January topped last year's by 13 per cent for same period, February's climbed 16 per cent. Shipments in February were up 8 per cent over January, compared to average increase for same period of 6 per cent.

—Modern Woodworking

On-the-job photo, Mid-State Wood Products Corp.

16 HOLES BORED IN ONE OPERATION

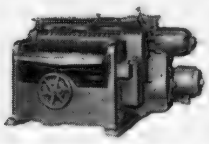
WITH GREENLEE NO. 386 GANG BORER

Here's another example of how the GREENLEE universal-spindle gang borer speeds production, assures accuracy of product. At Mid-State Wood Products Corp., Rockford, Illinois, this machine with one quick stroke bores 16 holes in fir plywood speaker panels for television sets. Due to its wide range and the convenience and simplicity of its adjustments, the GREENLEE is adapted to a great variety of boring work. Universal spindles can be quickly located at any point along the table . . . dozens can be used for one operation. Available in lengths from 4 to 16 feet to meet your exact production requirements.

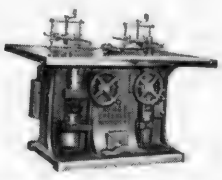
Write for Bulletin No. 386 **GREENLEE BROS. & CO.**
1756 Twenty-First Avenue, Rockford, Illinois.

GREENLEE WOODWORKING MACHINERY AND TOOLS
The GREENLEE line of woodworking machinery includes tenoners, mortisers, borers, saws, planers, and shapers.

GREENLEE DOUBLE-END TENONER . . . often called "a woodworking plant in itself." Renowned for quick, easy setup and wide versatility. Single-end Tenoners also made by GREENLEE.



GREENLEE SIX-ROLL SINGLE PLANER . . exceptionally smooth in operation. One of a line of single and double planers for fine work, high production.



GREENLEE MOTOR-DRIVEN SHAPER . . . all-around unit for high-speed, precision shaping. Double-spindle type, needs no separate frequency changer.

MORTISING AND BORING TOOLS . . . Countersinks, Hollow Chisels, Multi-Spur Bits, Machine Bits and other tools by GREENLEE mean top production from your woodworking machines.

MACHINERY & TOOLS
GREENLEE

FPRS NINTH NATIONAL MEETING HOST TO HUNDREDS AT SEATTLE, JUNE 21-24

- **Up to 750 Registrants Coming from All Sections of U. S., Canada, and Australia**
- **Ideal Time to Combine Vacation and Business**
- **Olympic Hotel Is Meeting Headquarters**
- **Technical Sessions and Events to Bring Out Latest Forest Products Developments—Encourage Interchange of Information Between Segments of Industry, Government, and Education**

DONNING INDIAN HEAD-DRESS to get in the mood for the Paul Bunyan Potlatch planned for the FPRS National Meeting in Seattle are John D. Ritchie, General Chairman, and Fred Armbruster, Arrangements Chairman. Ritchie, Armbruster, and Bill Hempleman, Potlatch Chairman, right, met with Chief Potlatcher Chester Ullin, left, to round out plans for the event.

SEATTLE, WASH.—This beautiful city of over 500,000 inhabitants, a shipping and operations hub for many forest products industries, will be the scene of the 1955 FPRS National Meeting the week of June 21–24.

An estimated 750 registrants and their families will enjoy an excellent technical program on latest forest products developments, outstanding social events, plus scenic Pacific Northwest tourist sights.

Registration

Registration desks will be staffed Monday, June 20, from 1–8:00 p.m.; and Tuesday, Wednesday, Thursday, June 21–23, from 8:00 a.m. to 5:00 p.m. The registration fee is $6 for members, $12 for non-members, and includes admission to technical sessions, plant tours ($3 bus fare extra for trip to Everett, Wash.), committee meetings and the Paul Bunyan Potlatch; as well as one set of abstracts of 63 papers to be presented at the technical sessions. Ladies registration fee is $7.50.

The official technical sessions will begin on the opening day of the meeting, Tuesday morning, June 21. For the next three days, registrants will have the opportunity to hear and participate in article presentations, panel discussions, and subject matter committee meetings. Registrants are welcome to attend any and all sessions and committee meetings.

Official Luncheon

Major items of interest will be the honoring of the incoming and outgoing Presidents, a speech by famed author Stewart Holbrook, and the presentation of awards and citations.

Hitchcock Publishing Co., publishers of Wood Working Digest, will present "Awards of Merit" to associations and firms in recognition of outstanding

(Continued on page 17-A)

Holbrook Speaks on "Daylight in the Swamp" at Official Luncheon

Stewart Holbrook, former logger and internationally famous writer, will speak on "Daylight in the Swamp" at the Official Luncheon, Tuesday noon, June 21, in the Spanish Ballroom of the Olympic Hotel. Vermont-born and the only exlumberjack to lecture at Harvard University, Holbrook is the author of more than a dozen books on the Pacific Northwest, lumbering, and historical subjects. He is a master story teller, with a keen sense of "story" and a gift of characterization.

Incoming and Outgoing FPRS Presidents to Be Honored

New President—Moss B. Christian

Director of Research for Chicago Mill and Lumber Co., Tallulah, La., President-Elect Christian will take office at the Ninth National Meeting.

Mr. Christian has enthusiastically served the Society in many important capacities since he joined in 1949. As South-Central Regional Board Member from 1949–52, he represented the Mid-South area of the U. S. and traveled extensively in behalf of FPRS affairs. Mr. Christian was General Chairman of the Society's 7th National Meeting held at Memphis, Tenn., in 1953; was elected Vice-President in 1953, and in 1954 became President-Elect. He is Program Chairman of this National Meeting in Seattle.

Receiving his M.S. degree from Louisiana State U. in 1938, Mr. Christian joined the Chicago Mill and Lumber Co. in the same year. He was named Director of Research in 1942.

Retiring President—Lester J. Carr

Completing a highly successful year of leadership during which he visited virtually every one of the 13 FPRS chapters, Mr. Carr crisscrossed the continent many times to become known as

M. B. CHRISTIAN

L. J. CARR

the Society's "flyingest" president. He will turn over the President's gavel to Moss B. Christian at the Official Luncheon, Tuesday noon, June 21.

Mr. Carr, who will remain on the Executive Board as Past-President, has been very active in FPRS affairs since he joined in 1948. One of the founding members of the Northern California Section, he served as Southwest Regional Board Member for three years. Mr. Carr was elected Vice-President at the 1952 National Meeting in Milwaukee, Wis.; President-Elect in 1953; and in 1954 he was Program Chairman at the Grand Rapids National Meeting.

He has been active in the lumber industry since 1923, forming his own company, L. J. Carr & Co., Sacramento, Calif., in 1935.

Official Technical Program

Forest Products Research Society, Ninth National Meeting

June 21, 22, 23, 24, 1955, Seattle, Washington

Olympic Hotel

SESSION I—COMPOSITION BOARD (Junior Ballroom: 9:00 a.m., Tuesday, June 21) Chairman: George G. Marra, Washington State Institute of Tech., Pullman, Wash. Presiding Chairman: Clark C. Heritage. Theme: Research and Progress in Composition Board Manufacture.

"Significant Factors for Establishing a Particle or Hardboard Plant"—S. C. Rooney, Columbia Eng. Co.

"Automation in the Hardboard Industry"—R. L. Campbell, American Mfg. Co.

"The Effect on Attrition Mill Particle Board of Type, Amount, and Method of Resin Application"—W. H. Cooke, Oregon Forest Products Laboratory.

"The Kriebaum Process for Extruded Core Board"—T. J. Connelly, The Dean Co.

"New Dry Process Multi-Ply Board"—J. d'A. Clark, Consultant.

SESSION II—WOOD DRYING (Parlors E & F; 9:00 a.m., Tuesday, June 21) Chairman: Leif Espenas, Oregon Forest Products Laboratory, Corvallis, Ore. Presiding Chairman: R. C. Rietz, U. S. Forest Products Laboratory, Madison, Wis. Theme: Wood's Behavior in Seasoning.

"Young-Growth Douglas-Fir: Is It Predisposed to Warp?"—J. D. Snodgrass, Oregon State College.

"Casehardening Stress Relief of Ponderosa Pine"—L. Winkel, Western Pine Assn. Research Laboratory.

"Vapor Drying of Western Woods"—W. R. Cantrell, Taylor-Colquitt Co.

"Some Variables Affecting the Shrinkage of Western Hemlock"—F. W. Guernsey, Forest Products Laboratory, U. of British Columbia.

"A New Type Cross Circulation Compartment Type Veneer Dryer"—J. W. Gottstein, Commonwealth Scientific Industrial Research Organization, and Denis Cullity, Westralian Plywoods Pty., Ltd., Australia.

"Improved Utilization through Modern Drying of Western Hardwoods"—H. H. Smith, California Forest & Range Experiment Station.

"Air Drying of Ponderosa Pine"—E. C. Peck, U. S. Forest Products Laboratory; Lincoln Mueller and Edward Kotok, Rocky Mountain Forest & Range Experiment Station.

SESSION III—LOGGING AND MILLING (Junior Ballroom; 2:00 p.m., Tuesday, June 21) Chairman: Fred C. Simmons, U. S. Forest Service, Upper Darby, Pa. Theme: Logging Second-Growth Stands and Milling Their Products.

"Needed: Economical New Methods of Logging Second-Growth Western Softwoods"—E. E. Matson, Pacific Northwest Forest Experiment Station.

"New Developments in Logging Small Softwoods in the East and South"—B. Mety, Southern Lumber Co.

"New Developments in Milling of Small Softwoods"—D. Thomas, U. of Washington.

"Logging Small Hardwoods"—L. Hooker, Michigan College of Mining & Technology.

"Sawing Small Hardwoods for Grade with the Short-Log Bolter"—G. E. Bell and W. W. Calvert, Forest Products Laboratories of Canada.

"Integrated Utilization of Hardwoods"—L. F. Whittemore, Brown Co.

"Economics of Debarking Redwood Logs"—W. H. Parks, Simpson Redwood Co.

"Skidding Resistances Encountered in Hardwood Logging"—D. E. Herrick, Central States Forest Experiment Station.

"Pulp Chips and Tanbark from Hemlock Slabs in Air Flotation"—N. F. Roger, E. L. Griffin, Jr., C. S. Redfield, Eastern Utilization Research Branch of Agricultural Research Service; and W. H. Koepp, Michigan College of Mining & Technology.

SESSION IV—SMOG CONTROL, ELECTRIC DRIVES, & WOOD PRESERVATION (Parlors E & F; 2:00 p.m., Tuesday, June 21) Chairman: Ira Hatfield, Monsanto Chemical Co., St. Louis, Mo. Presiding Chairman: John B. Grantham, Oregon Forest Products Laboratory, Corvallis, Ore.

"Air Pollution and the Forest Products Industries"—E. S. Feldman, Furniture Mfrs. Assn. of So. Calif.

"Modern Electric Drives for the Lumber Industry"—W. L. Lagers, General Electric Co.

"Relationship of Oil Carriers to Utility of Pentachlorophenol as a Wood Preservative"—Ira Hatfield and S. S. Sakornbut, Monsanto Chemical Co.

"Pentachlorophenol Gradients in Pressure Treated Wood Under Exposure to Weather"—W. C. Kelso, Jr., E. A. Behr, R. E. Hill, Jr., Chapman Chemical Co.

"Facilitating Research by Use of the IBM System"—C. S. Walters, Illinois Agricultural Experiment Station

SESSION V—PACKAGING (Junior Ballroom; 9:00 a.m., Wednesday, June 22) Chairman: Kenneth W. Kruger, U. S. Forest Products Laboratory, Madison, Wis. Presiding Chairman: A. M. Fielding, Supt., Transcontinental Freight Bureau, San Francisco, Calif. Theme: Container Materials from the Forests.

"Paper-Overlaid Veneer Applications"—J. Foley, Weyerhaeuser Timber Co.

"Use of Plywood in Containers"—D. Countryman, Douglas Fir Plywood Ass'n.

"Fiberboard Containers"—J. D. Malcolmson, Consultant to Robert Gair Co.

"Wooden Boxes and Crates"—C. O. Thompson, The Wooden Box Institute.

"Consumer's Viewpoint"—C. B. Moore, Western Growers Ass'n.

SESSION VI—CHEMICAL UTILIZATION (Parlors E & F; 9:00 a.m., Wednesday, June 22) Chairman: Reavis C. Sproull, Herty Foundation Laboratory, Savannah, Ga. Presiding Chairman: Herbert B. McKean, Potlatch Forests, Inc., Lewiston, Idaho. Theme: Use the Whole Tree.

"New Potentials in Fibers and Chemicals from Wood Waste"—F. H. Snyder, consultant.

"Chemical Resistance of Western Woods"—J. D. Ross, Oregon Forest Products Laboratory.

"Chemical Research on the Utilization of Waste Lignin"—E. E. Harris, U. S. Forest Products Laboratory.

"Whole Wood as a Potential Source for Shaped Articles"—A. K. Easter, Weyerhaeuser Timber Co.

"The Strength & Properties of Plantation-Grown Slash Pine"—P. R. Kramer, Texas Forest Service.

(Continued on page 17-A)

Timetable of Events

All Technical Sessions and Committee Meetings Will Be Held in the Olympic Hotel, Convention Headquarters

	MONDAY June 20	TUESDAY June 21	WEDNESDAY June 22	THURSDAY June 23	FRIDAY June 24
7:15 a.m.				Authors' Breakfast (morning technical sessions) Parlor B Authors' Breakfast (afternoon technical sessions) Parlor C	
7:30 a.m.		Authors' Breakfast (morning technical sessions) Parlor B Authors' Breakfast (afternoon technical sessions) Parlor C	Authors' Breakfast (morning technical sessions) Parlor B Authors' Breakfast (afternoon technical sessions) Parlor C		All-day Field Trip to Everett, Wash.
8:00 a.m.		Registration Mezzanine	Registration Mezzanine	Registration Mezzanine	
8:30 a.m.				Technical Session IX Veneer and Plywood Junior Ballroom Technical Session X Wood Machining Parlors E and F	
8:45 a.m.				Subject Matter Committee Meetings: Wood Drying—Parlor A Chemical Utilization—Parlor B Packaging—Parlor C	
9:00 a.m.		Technical Session I Composition Board Junior Ballroom Technical Session II Wood Drying Parlors E and F	Technical Session V Packaging Junior Ballroom Technical Session VI Chemical Utilization Parlors E and F		
9:30 a.m.		Subject Matter Committee Meetings: Wood Finishing—Parlor A Glues and Gluing—Parlor B Logging and Milling—Parlor C	Subject Matter Committee Meetings: Marketing—Parlor A Composition Board—Parlor B Veneer and Plywood—Parlor C		
10:00 a.m.	FPRS Executive Board Meeting Parlor 1				
11:15 a.m.				FPRS Business Meeting Junior Ballroom	
12:00 Noon		FPRS Official Luncheon Spanish Ballroom		Sec. Officers' Advisory Committee and Executive Board Luncheon Parlor A	
1:00-8:00 p.m.	Registration Mezzanine				
1:30 p.m.			Technical Session VII Glues and Gluing Junior Ballroom Technical Session VIII Education Parlors E and F Subject Matter Committee Meetings: Wood Preservation—Parlor A Quality Control—Parlor B	Technical Session XI Marketing Junior Ballroom Subject Matter Committee Chairmen Meeting Parlor 1	
2:00 p.m.		Technical Session III Logging and Milling Junior Ballroom Technical Session IV Smog Control, Electric Drives, and Wood Preservation Parlors E and F Subject Matter Committee Meetings: Education—Parlor A Wood Machining—Parlor B	Informal Plant Tours		
4:00 p.m.				Paul Bunyan Potlatch	
7:30 p.m. to Midnight			FPRS Party (Reception, Dinner, Entertainment, Dancing) Spanish Ballroom		
7:30 p.m.	Membership Committee Meeting Parlor D				
8:30 p.m.	Employment Committee Meeting Parlor 1				

why fire ladders are made of wood!

Generations of firemen have battled smoke and flame from wooden ladders. For even though it is combustible, wood has proven superior to other materials on many counts. It is strong, easy to fabricate and maintain and a nonconductor of heat and electricity. For these reasons, wood is still preferred by many fire departments.

In recent years the long, select, clear wood required for ladder beams has become more and more difficult to obtain. And so ladder manufacturers have turned to laminating ladders. Using modern plastic adhesives such as Borden's CASCOPHEN, a waterproof resorcin resin, they have produced a ladder that is stronger and safer than the solid beam type.

Making wood better than wood with adhesives has been Borden's stock in trade for over 25 years. Perhaps you have a material problem where this experience can be of assistance. If so, write The Borden Company, Chemical Division, Dept. BW-35, 350 Madison Avenue, New York 17, N. Y.

ADHESIVES * CASEIN * INDUSTRIAL CHEMICALS
RESINS * POLYMERS * MOLDING COMPOUNDS

THE Borden COMPANY
CHEMICAL DIVISION

Technical Program

(Continued from page 12-A)

SESSION VII—GLUES AND GLUING (Junior Ballroom; 1:30 p.m., Wednesday, June 23) Chairman: Alan A. Marra, School of Natural Resources, U. of Michigan, Ann Arbor, Mich. Program Planning: Ben S. Bryan U. of Washington; Donald V. Redfern, American-Marietta Co., Seattle, Wash. Theme: The New Look in Glues and Gluing.

"A Non-Destructive Test for Glue Lines in Laminated Wood"—F. F. Wangaard and B. A. Jayne, Yale U.

"A Survey of Strength Tests of Glue Joints"—J. M. Yavorsky and J. H. Cunningham, N. Y. State College of Forestry, and N. G. Hundley, Edge Grain Timber Structure, Inc.

"What's New in Veneer Edge Gluing Techniques"—J. W. Mann, Mann-Russell Electronics, Inc.

"Gluing Developments Related to the Navy's Shipbuilding Program"—J. Kuenzel, Bureau of Ships, and W. H. Miles, Puget Sound Naval Shipyard.

"First Report on a New Method for Evaluating Interior Plywood"—H. W. Haigh, American-Marietta Co.

"Hot Press Gluing of Hardboards to Douglas Fir Veneers with Phenolic Resin Adhesives"—F. J. Shelton, Reichhold Chemicals, Inc.

"Progress in the Gluing of Hard-Grained Fir Veneer"—R. K. Stensrud, Reichhold Chemicals, Inc.

SESSION VIII—EDUCATION (Parlors E & F; 1:30 p.m., Wednesday, June 23) Chairman: A. J. Panshin, Michigan State College, East Lansing, Mich. Program Planning: James S. Bethel, N. C. State College, Raleigh, N. C. Theme: Short Courses, Refresher Courses and Similar Aids to Industry.

"The Place of Basic Courses in the Forest Products Curriculum"—D. Gordon Marckworth, Univ. of Washington.

"Vocational Training Through Industrial Short Courses"—W. R. Smith, Southeastern Forest Experiment Station.

On-The-Job Orientation Training for Technical Personnel"—L. F. Maybach, Crown Zellerbach Corp.

"Recruitment and Training of Technical Personnel for Work in the Adhesives Industry"—Monsanto Chemical Co.

"Professional Development of Technical Personnel on the Job"—R. E. Baker, Weyerhaeuser Timber Co.

SESSION IX—VENEER AND PLYWOOD (Junior Ballroom; 8:30 a.m., Thursday, June 23) Chairman: H. O. Fleischer, U. S. Forest Products Laboratory, Madison, Wis. Presiding Chairman: O. Harry Schrader, Jr., U. S. Plywood Corp., Seattle, Wash. Program Joint-Chairmen: James R. Roberts, Weyerhaeuser Timber Co., Longview, Wash.; H. O. Fleischer, U. S. Forest Products Lab., Madison, Wis. Theme: Plywood: A Big Future for a Better Wood.

"What Effect Will Hardboard, Particle Board and Similar New Products Have on Traditional Plywood Markets"—T. Smetana, Weyerhaeuser Sales Co.

"Factors Minimizing Face Checking of Plywood"—T. E. Batey, Jr., Douglas Fir Plywood Assn.

"Is Plywood an Engineering Material?"—Panel Discussion. Moderator—Charles B. Norris, U. S. Forest Products Laboratory. "Use of Plywood in Engineered Structures"—M. Von Berlichingen, Harnischfeger Corp. "Mechanical Properties of Plywood"—F. F. Wangaard, Yale U. "Engineering Aspects of Current and Proposed Standards for Plywood"—D. Countryman, Douglas Fir Plywood Assn., and —, Hardwood Plywood Institute.

SESSION X—WOOD MACHINING (Parlors E & F; 8:30 a.m., Thursday, June 23) Chairman: L. A. Patronsky, Wabash Screen Door Co., Minneapolis, Minn. Theme: Faster, Safer and Better Machining.

"An Analysis of the Lumber Planing Process"—Peter Koch, Consultant.

"U. S. Navy Experience with Carbides Applied to Woodworking Machines"—T. Kelley, U. S. Bureau of Ships.

"Saving Lumber through Blanking with the Two-Way Thicknessing Planer"—C. W. Jones, Stetson-Ross Machine Co.

"Surfacing of the Western Pines and Associated Woods"—H. Logan, Corpus Christi, and D. C. Brice, Western Pine Assn. Laboratories.

SESSION XI—MARKETING (Junior Ballroom; 1:30 p.m., Thursday, June 23) Chairman: P. H. W. Creden, Edward Hines Lumber Co., Chicago, Ill. Theme: Marketing Forest Products Now and in the Future.

"Advertising and Public Relations in the Wood Industry"—Panel Discussion.

"Lumber Manufacturer Point of View"—P. H. W. Creden, Edward Hines Lumber Co.

"Fundamental Market Research"—M. A. Foland, Pacific National Advertising Agency.

"Department Store-Luggage Manufacturer Point of View"—H. Kotkins, Skyway Luggage Co.

"Retail Lumber Dealer 'Do-It-Yourself' Point of View"—R. Blackstock, Blackstock Lumber Co.

On the Cover

FPRS President Moss B. Christian is the co-holder of several patents assigned to the Chicago Mill and Lumber Co., where he is Director of Research. One of his notable achievements was in the development of "Craveneer", a kraft paper-covered veneer which is assuming increasing importance in the nation's packaging industry.

In the Craveneer process, the paper face and back are laminated to the green veneer ribbon. The panel is dried later through a continuous roller type steam kiln.

The cover photo shows the laminated green panel after being roller pressed, and just prior to being clipped to desired width.

Earlier in his career, Mr. Christian was engaged in entomology work, particularly on insects which attack wood products. He is the author of numerous articles on control of insect damage.

"Need for Trained Manpower Point of View"—R. M. Carter, N. C. State College.

"Advertising and Public Relations Point of View"—Perry Culp, Jr., Cole & Weber Advertising Agency.

National Meeting

(Continued from page 11-A)

service in the promotion of wood and wood utilization.

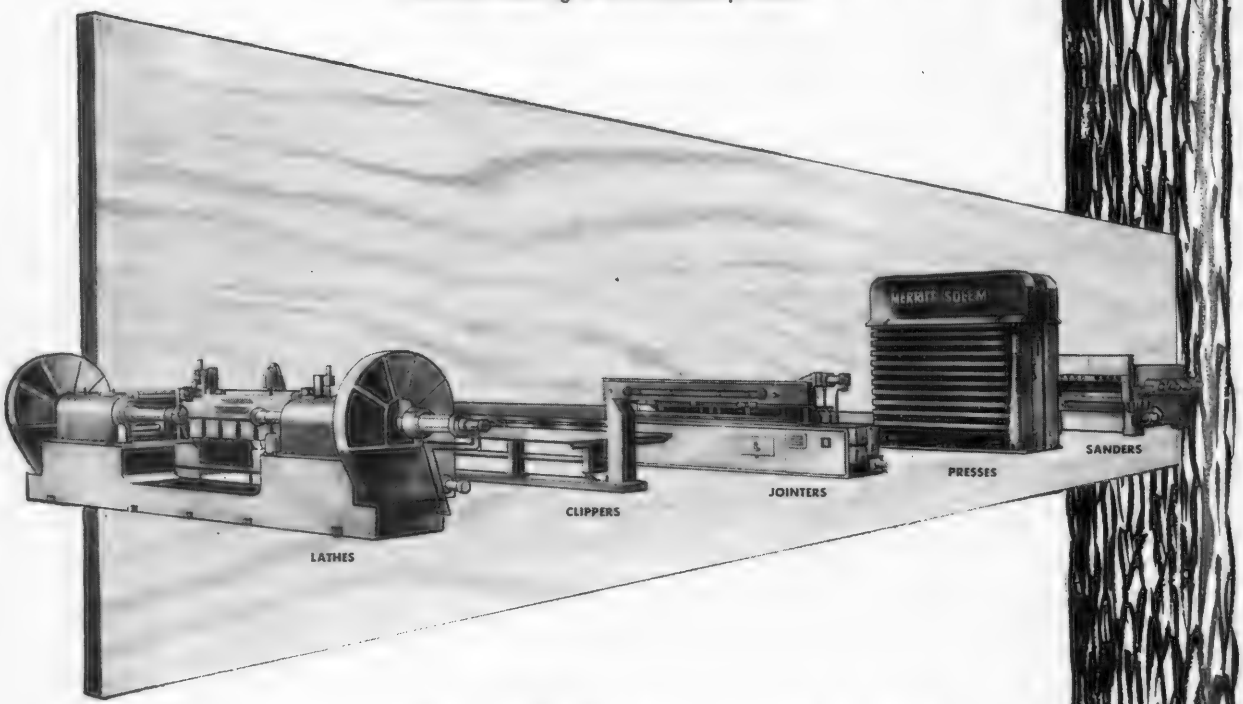
Certificates and cash awards for outstanding university research in forest products will go to the top undergraduate and graduate papers entered in the 6th Annual "Wood and Wood Products Awards" contest sponsored by Wood and Wood Products magazine, Chicago. The graduate winner will receive $350 and the undergraduate winner will receive $150.

Employment Service

As customary, there will be an informally-conducted employment service during the National Meeting. Chairman Newell Norton and members of his committee will be available for private interviews Tuesday, June 21, 2 to 5 p.m.; Wednesday, June 22, 9 a.m. to 12 noon; and Thursday, June 23, 9 a.m. to 11 a.m. Note: This service is both for employers who are seeking men and for men who are looking for positions. The interview room number will be posted at the Registration Desk.

RIGHT
DOWN THE LINE

You're right — when you have Merritt-Solem equipment right down your veneer and plywood production line. Because . . . profitable production of veneer and plywood depends on an uninterrupted flow of material from the log to the finished product.



To obtain this kind of production, the best line to follow, is the Merritt-Solem line . . . from veneer lathe to clipper to jointer to press to sander . . . and to complete the line Merritt-Solem designs and builds conveyors to suit your requirements. Others have done it . . . ask any one who has MERRIT-SOLEM EQUIPMENT. The next time you need veneer or plywood machinery, think of "profitable production through dependable equipment" and contact Merritt-Solem. In fact, it would be a good idea to have information handy in your file . . . so why not drop Merritt-Solem a card or a letter and we'll send you a complete catalog.

MERRITT-SOLEM

DIVISION OF
SOLEM MACHINE COMPANY
120 S. NIAGARA ST. LOCKPORT, N. Y.

PAUL BUNYAN POTLATCH HIGHLIGHTS SOCIAL EVENTS AT NATIONAL MEETING

- **Sponsored by 60 Wood Industry Suppliers**
- **Scenic Ferry Boat Ride**
- **Naval Shipyard Tour**
- **Twanoh State Park Site of Potlatch**
- **Delicious Salmon Fillets and Appetizers**
- **Indian Dancers in Native Costumes**
- **Prizes**

The streamlined ferry Kalakala will take FPRS registrants from Seattle to Bremerton en route to the Paul Bunyan Potlatch. Kalakala is an Indian name meaning Flying Bird.

What's a Potlatch?

And what has Paul Bunyan got to do with it?

These are questions some 750 registrants will find delightful answers to at Seattle.

Paul Bunyan was a man of the woods, as are all members of FPRS—one way or another. A Potlatch is an old Pacific Northwest Indian ceremonial that brought the tribes together once a year to air grievances, give information, exchange gifts, enjoy dancing, and consume tasty foods cooked over the open fire.

So, combine the symbolism of Paul Bunyan and Potlatch and you have it! The men of the woods will have spent three days airing grievances and passing out information by Thursday evening. By that time every one will be ready to exchange gifts, watch some dancing, and enjoy feasting. And 60 suppliers are the hosts for this unusual evening of entertainment for the FPRS men and their wives.

Chef Chet Ullin, Pacific Northwest Potlatch authority, gives large fillets of Chinook salmon a turn over the fire in preparation for a feast.

The cool green of Pacific Northwest forests will provide an inviting atmosphere at Twanoh State Park, site of the Paul Bunyan Potlatch. All registrants and their families will be the guests of suppliers at the colorful ceremonial feast on Thursday evening, June 23.

Indian dances in native surroundings will provide a taste of the colorful Northwest to Potlatch guests.

Shipyard Tour

The Paul Bunyan Potlatch starts from Convention Headquarters at the Olympic Hotel. Busses start loading at 4 p.m. to take the conventioners aboard a ferry boat for the 18-mile water trip to Bremerton, Wash. In Bremerton, the busses will pass through the U. S. Naval Shipyards to give the group a quick look at the building and repair of warships.

Following the Navy Yard tour, the busses will wind their way over Washington highways that penetrate cool and green forests to Twanoh State Park. The park, site for the Paul Bunyan Potlatch, is on the wooded shores of Hood Canal and not far from Olympic National Park.

Arrival at the park will be approximately 6:15 p.m. Chief Potlatcher Chet Ullin and his crew of Potlatchers will have spent the day over a hot open fire to prepare many hundreds of pounds of freshly caught Chinook Salmon. Appetizers of clam nectar, buttered clams, and kippered salmon will be ready for the group on arrival. A word of warning: Don't over-whet your appetite with appetizers. The big salmon, weighing from 10 to 30 pounds,

(Continued on page 23-A)

MEET THE AUTHORS AND CHAIRMEN FOR THE FPRS NINTH NATIONAL MEETING

More than 100 experts in various forest products fields are contributing to the Ninth National Meeting as authors, committee chairmen, and session chairmen. They are participating in 11 technical sessions and 13 committee meetings, open to all registrants.

T. E. BATEY, Jr.

E. A. BEHR

G. E. BELL

J. S. BETHEL

R. BLACKSTOCK

D. C. BRICE

W. W. CALVERT

R. M. CARTER

J. d'A. CLARK

T. J. CONNELLY

W. H. COOKE

D. COUNTRYMAN

P. H. W. CREDEN

D. CULLITY

J. H. CUNNINGHAM

L. ESPENAS

A. K. ESTERER

E. S. FELDMAN

A. M. FIELDING

H. O. FLEISCHER

J. FOLEY

J. W. GOTTSTEIN

J. B. GRANTHAM

H. W. HAIGH

E. E. HARRIS

I. HATFIELD

C. C. HERITAGE

D. E. HERRICK

R. E. HILL, Jr.

L. W. HOOKER

N. G. HUNDLEY

C. W. JONES

T. M. KELLEY

W. C. KELSO, Jr.

W. H. KOEPP

P. R. KRAMER

K. W. KRUGER

J. KUENZEL

H. LOGAN

J. D. MALCOLMSON

J. W. MANN

G. MARCKWORTH

A. A. MARRA

G. G. MARRA

E. E. MATSON

L. F. MAYBACH

H. B. McKEAN

W. H. MILES

C. B. MOORE

C. B. NORRIS

A. J. PANSHIN

W. H. PARKS

L. A. PATRONSKY

E. C. PECK

R. C. RIETZ

N. F. ROGER

J. D. ROSS

S. S. SAKORNBUT

O. H. SCHRADER, Jr.

F. J. SHELTON

F. C. SIMMONS

T. SMETANA

H. H. SMITH

It's never too wet for Presdwood!

Douse it. Dunk it. Submerge it for years*. Masonite Tempered Presdwood® resists water indefinitely. Water won't dilute its advantages.

Unlike the wood from which it comes, Presdwood has no grain or knots to plague the production man. Never rots or corrodes, splits or cracks. Never deteriorates under severest climatic conditions—finishes stay new looking longer.

This stubborn stability is just one of the many reasons why Presdwood panels are so welcome a component in products. Too, they combine with wood, metal, plastics, fabrics—cutting production costs, increasing quality. At present there are 44 types and thicknesses of Presdwood products ready to serve you. For the aid of a Masonite sales engineer, write Masonite® Corporation, Dept. FPJ-6, Box 777, Chicago 90, Ill.

*Thousands of square feet of Masonite Tempered Presdwood went into a "sea wall" along Chicago's lake front. After nine icy winters and steaming summers, the panels showed no discernible change in size or shape.

Leading manufacturers of prefabricated homes use Presdwood for siding, gables, doors and walls.

Juvenile furniture and toy manufacturers select Presdw[illegible] for beds, chests, play pens, doll carriages, and toys of all kin[illegible]

Choose This Man He Makes The Difference

MASONITE CORPORATION

MANUFACTURER OF PRESDWOOD PANEL PRODUCTS

R. L. SMITH

W. R. SMITH

J. D. SNODGRASS

F. H. SNYDER

R. C. SPROULL

R. K. STENSRUD

C. O. THOMPSON

C. S. WALTERS

F. F. WANGAARD

L. F. WHITTEMORE

L. WINKEL

J. M. YAVORSKY

Paul Bunyan Potlatch

(Continued from page 19-A)

are to be prepared by several open-fire methods—and they are all delicious.

After the tasty salmon feast, the entertainment of Pacific Northwest and Plains Indian dances will take place around the fire. Several interpretations of dances will be given in native attire. Indian tribes of the Pacific Northwest wore a different type of head-dress than the Plains Indians and the comparisons will prove interesting.

Before the party boards the busses for the homeward trek, the Pacific Northwest Section of FPRS will make presentations to some of those attending the Paul Bunyan Potlatch. Keys to the prize list will be a part of the registration.

A Potlatch is an informal affair. Sports clothes are in order with a jacket to keep out the breezes. The return trip to Seattle will be over the same route with the moonlight ferry trip from Bremerton to Seattle a fitting climax to an eventful evening.

FPRS Salutes Your Potlatch Sponsors

Sixty companies supplying services and materials to the wood industry have generously underwritten the principal cost of the Paul Bunyan Potlatch. They have invited you, the FPRS registrants and your families, to be their guests for an enjoyable evening of sight-seeing, entertainment, and fun. The sponsors are:

The American Defibrator, Inc., New York, New York
American Manufacturing Co., Inc., Tacoma, Washington
American-Marietta Co., Seattle, Washington
Automatic Sprinkler Corp. of America, Seattle, Washington
The Borden Co., Seattle, Washington
Burke Millwork Co., Seattle, Washington
The Carborundum Co., Niagara Falls, New York
Crown Zellerbach Corp., Seattle, Washington
Henry Disston & Sons, Inc., Seattle, Washington
The Dow Chemical Co., Midland, Michigan
Elliott Bay Mill Co., Seattle, Washington
Fjellman American, Inc., Joliet, Ill.
Forest Interiors Manufacturing Co., Seattle, Washington
Foss Launch & Tug Co., Tacoma, Washington
Gerlinger Carrier Co., Dallas, Oregon
Industrial Woodworking, Greenwich, Connecticut
Curt G. Joa, Inc., Sheboygan Falls, Wisconsin
McManama & Co., Seattle, Washington
Mann-Russell Electronics, Tacoma, Washington
Masonite Corp., Chicago, Illinois
Mattison Machine Works, Rockford, Illinois
Merco Industries, Inc., Seattle, Washington
Mereen-Johnson Machine Co., Minneapolis, Minnesota
Milwaukee Boom Co., Tacoma, Washington
Monsanto Chemical Co., Seattle, Washington
Moore Dry Kiln Co., North Portland, Oregon
National Casein Co., Chicago, Illinois
Nicholson Manufacturing Co., Seattle, Washington
Oliver Machinery Co., Grand Rapids, Michigan
The Pacific Lumber Co., Chicago, Illinois
Perkins Glue Co., Lansdale, Pennsylvania
Philadelphia Quartz Co. of California, Berkeley, California
E. V. Prentice Co., Portland, Oregon
Production Management Engineering Association, Inc., Portland, Oregon
Protection Products Manufacturing Co., Kalamazoo, Michigan
The Quaker Oats Co., Portland, Oregon
Reichhold Chemicals, Inc., New York, New York
Rockwell Manufacturing Co., Oakland, California
Simonds Saw & Steel Co., Portland, Oregon
Star Machinery Co., Seattle, Washington
Stetson-Ross Machine Co., Seattle, Washington
Sumner Iron Works, Sumner, Washington
Tallman Machinery Co., Seattle, Washington
Titan Chain Saws, Inc., Seattle, Washington
United States Plywood Corp., Seattle, Washington
Van Waters & Rogers, Inc., Seattle, Washington
Washington Machinery Co., Seattle, Washington
Weyerhaeuser Timber Co., Tacoma, Washington
Wienker Machinery Co., Seattle, Washington
Williams Patent Crusher & Pulverizer Co., St. Louis, Missouri
Yates-American Machine Co., Beloit, Wisconsin

Monsanto Profit Pointer

What lean meat is to any stew ...**melamine** is to plywood glue!

UPGRADE YOUR BONDS WITH LITTLE OR NO INCREASE IN COST—USING LAUXITE* MF300

Test after test has proved it conclusively. Melamine improves the bonding power and durability of any urea resin adhesive . . . *with little or no extra cost.*

Even small increments of Lauxite MF300—a special Monsanto melamine resin formulated for the plywood industry—give remarkable water resistance, more stable glue mixes and less critical assembly times. Hot-weather problems are also minimized.

If you are using 30-35 parts of wheat flour, you can upgrade your bond by adding 10% melamine to your urea mix—and reduce your glue spread under normal conditions from 40 lbs. M. S. G. L. to 30 lbs. M. S. G. L., thereby maintaining comparable manufacturing cost.

A 10% melamine addition to your urea mix will provide high resistance to delamination in boiling, ranging from ½ hour to approximately 4 hours—depending on wood species.

For technical information on how melamine resin can upgrade your bonds, write Monsanto Chemical Company, Plastics Division, Dept. FP6, Springfield 2, Mass.

FIR PLYWOOD 1905 1955 GOLDEN JUBILEE

MONSANTO

*LAUXITE: REG. U.S. PAT. OFF.

SOCIETY NEWS

Five Companies Enroll As FPRS Supporting Members

Five companies have recently joined the ranks of FPRS as supporting members interested in keeping abreast of progressive methods of manufacturing and processing forest products. The firms and their designated FPRS representatives are: **Biles-Coleman Lumber Co.**, Omak, Wash., Ross L. McNett, Pres., Gen. Mgr., and Treas.; **Cascade Lumber Co.**, Yakima, Wash., S. B. Moser, Vice-Pres. and Gen. Mgr.; **Diamond Match Co.**, Spokane, Wash., O. E. Miller, Auditor, Northwest Operations; **Wynnewood Products Co.**, Jacksonville, Texas, Thomas B. Johnson, Vice-Pres. and Gen. Mgr.; and **Georgia-Pacific Plywood Co.**, New York, William A. Merigold, Mgr., Plastic Plywood Div.

The Biles-Coleman Lumber Co. saws more than 200,000 bd. ft. of lumber per day for re-manufacture into other products. The company's principal products are casket shook, window frames, furniture, and other diversified items.

Officers of the firm are: R. L. McNett, President, General Manager, and Treasurer; J. E. Maley and R. F. Taylor, Vice-Presidents; A. M. Aston, Secretary and Sales Manager; A. Huggins, Assistant Secretary; and John McNett, Plant Supt.

Sales representatives are R. F. Taylor, Great Neck, L. I., and H. M. Tripp, Crystal Lake, Ill.

Many improvements have been made in recent years in the 700-employee plant. In the sawmill a modern re-saw was added in conjunction with band and gang saws. The latest piece of equipment is an electronic gluing machine. At the time of installation, the latter was the largest ever made and one of the first to be equipped with a traveling cut-off saw.

Founded by J. C. Biles in 1921, the firm's first diversification started in 1922 with the sawing of stock for window and door frames. In 1924 the firm began manufacture of window and door frames and built a new sawmill adjacent to the factory. A fire destroyed the sawmill and power plant in 1928. These were replaced with an all-electric sawmill, one of the first such mills in operation.

Ross L. McNett

FPRS News-Digest, Continued

Aerial view of Biles–Coleman Lumber Co., Omak, Washington

FPRS Executive Board Invited To Pacific Southwest Meeting

FPRS Executive Board members have been invited to attend the summer meeting of the Pacific Southwest Section in Los Angeles June 29 by Chairman E. S. Feldman, Jr.

Feldman is presenting a paper at the National Meeting on "Air Pollution and the Forest Products Industries." He is executive secretary of the Furniture Manufacturers Assoc. of Southern California.

Sponsor Surveys Opinion on "Wood Award" Competition

Continuation of the "Wood Awards" was overwhelmingly favored in a recent poll by Wood & Wood Products magazine, sponsor of the annual awards. Benefits, it was pointed out, are gained not only from the winning papers themselves, but also from the direction and attention the activity draws to research in the industry.

The poll was made among 30 key individuals representing all interested segments of the industry, following consultation of the sponsors with the Education Committee of FPRS. The awards for papers on student-conducted research are presented annually at the FPRS National Meeting.

Among those replying, 83 per cent felt that the awards should be continued. Some suggested that an award be added for research by a working member of the industry, even if the award were a certificate or plaque, with no money prize. However, 87 per cent voted against broadening the present competition to include working members of industry.

Because of wide differences of opinion on some questions on the poll, the editors are urging the entire industry to submit their opinions of the awards. Answers are being solicited to the following questions: Should the "Wood Awards" be continued as at present? Should the present basis of permitting students to submit papers on subjects of their own choosing be changed to provide for selection and assignment of subjects by the sponsors? Should the annual competition be restricted to graduate students? If restricted to graduate students, should there be a first and second award? Should the competition be changed entirely to cover only working members of the industry? Can you suggest any more appropriate plan which will have greater significance and practical value to the industry's working members than the present student awards?

Submit your answers to these questions to: Wood and Wood Products Magazine, 139 N. Clark St., Chicago 2, Ill.

Student Membership Awarded

Daniel A. Rascher, U. of Missouri junior in forest products marketing, has been given a FPRS Student Membership as winner of the Department of Forestry Junior Award, it has been announced by R. H. Westveld, Department Chairman.

LEADERSHIP IN THE PLANER MATCHER FIELD SINCE 1907

This Trade Mark

ON MACHINES IN YOUR PLANT MEANS

HIGHEST PRODUCTION
MAXIMUM QUALITY
LOWEST PRODUCTION COST

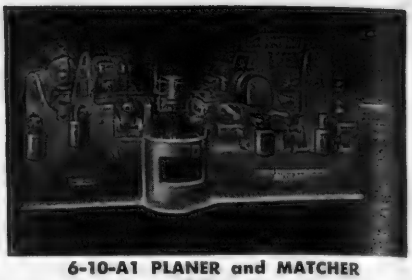
THE most profitable planing mills in operation today are those planned for continuous straight-line production and minimum lumber handling. The heart of such a production line is a quick-change, fast feed modern planer and matcher that produces finely machined lumber—and does it a full 8 hours per shift. There is no place in *today's* planing mill for the machine that ties up production a half hour or more each time a pattern is changed.

New machine developments during the last 20 to 25 years have made the equipment of an earlier era obsolete—*obsolete long before it is worn out.*

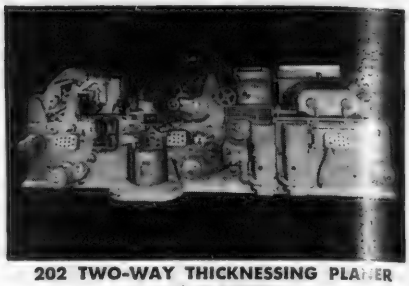
If you are using ancient machines in your planing mill just because they aren't *worn out* yet, we suggest that you honestly compare the equipment you are now using with the available new equipment on the market. Then, determine how much this obsolescence is actually costing you.

We believe you will be agreeably surprised at the many *years-ahead* features found in Stetson-Ross cost-reducing planing mill machines.

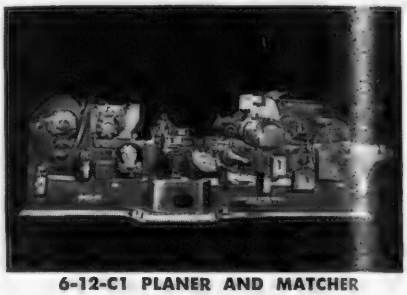
You are invited to submit planing, trimming or handling problems for our recommendations without obligation. FREE ON REQUEST: *Your copy of "A B C's of Planing Mill Layout."*



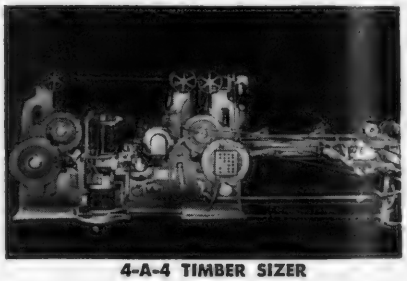
6-10-A1 PLANER and MATCHER
(8 Knife)



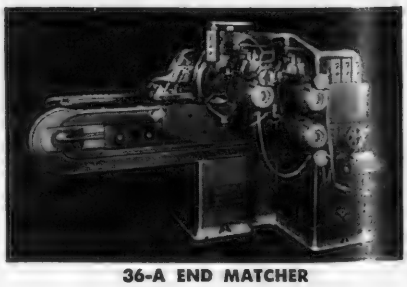
202 TWO-WAY THICKNESSING PLANER and MATCHER
(14 Knife)



6-12-C1 PLANER AND MATCHER
(14 or 16 Knife)



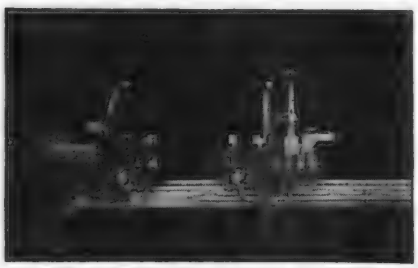
4-A-4 TIMBER SIZER



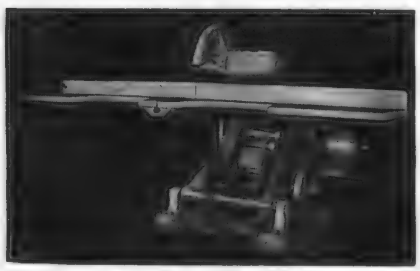
36-A END MATCHER

TRAVELING APRON DECK-CONVEYOR
603-E UNLOADER HOIST

T-33 RANDOM LENGTH TRIMMER
with built-in top and bottom dust removal system



WT-65 AUTOMATIC BUNDLE TRIMMER



T-18 CUT-OFF SAW

STETSON-ROSS MACHINE COMPANY
SEATTLE 4, WASHINGTON

EXPORT DIVISION: 301 CLAY ST., SAN FRANCISCO 11, CALIFORNIA

INDUSTRY NEWS

FPRS News-Digest, Continued

NLMA Revises Formats of Lumber And Flooring Statistical Reports

Several improvements in presentation of its statistics on lumber and hardwood flooring have been announced by the National Lumber Manufacturers Assoc.

The Monthly Statistical Report on Lumber and Hardwood Flooring now includes line and bar graphs to show relationships between estimates of total production, shipments, new orders, unfilled orders, and gross mill stocks, and to compare present figures with previous years. The statistics will also be presented in tabular form.

NLMA is offering the Monthly Statistical Report and the weekly National Lumber Trade Barometer on a subscription basis. The weekly Barometer, which records current trends of approximately 500 reporting mills, is offered for $5 per year. The Monthly Statistical Report, including a semiannual Statistical Summary, is available for $2 per year.

British Columbia Set Log Production Record in 1954

Log production in British Columbia reached an all-time high of 5,567 million board feet in 1954, J. S. Johannson of MacMilland & Bloedel, Ltd., told the B. C. Loggers Assoc. at a recent annual meeting. The 5 per cent increase above 1953 production was entirely recorded in the Vancouver District, a slight decrease occurring in the Interior.

The number of accidents per million board feet logged has been cut by 59 per cent since organization of the association's accident prevention division in 1947, Johannson reported. However, the average amount per compensation claim has increased 2½ times in the same period, he pointed out.

Ottis Hallin of Crown Zellerbach Canada, Ltd., was elected new chairman of the association.

New York Forestry College Continues Preservative Study

Fungi research at the State University of New York College of Forestry, Syracuse, will be continued under a $10,400 grant awarded to the college by the Army Quartermaster Corps. This is a renewal of a project begun in 1953 to study effectiveness of various wood preservatives against destructive fungi. Field tests are being made in the vicinity of Syracuse, N. Y., and Gulfport, Miss.

Raymond A. Moore, research assistant, is project leader, under the direction of Dr. Robert A. Zabel, associate professor of botany.

Quality control short course at State University of New York College of Forestry, Syracuse, April 12–16, attracted wood industry representatives from California, Massachusetts, Vermont, Ontario, and Quebec, as well as New York. Dr. Aubrey E. Wylie of college faculty measures thickness of board as step in collection of data for plotting on a control chart.

Seven Species Dominate California Timber Production

California forests contain 360 billion board feet of sawtimber, according to a report "Forest Statistics for California," just issued by the Forest Service, U. S. Dept. of Agriculture.

Based on a recent survey, the report shows that seven tree species make up nearly 90 per cent of the state's total sawtimber. Douglas-fir leads with a volume of 117 billion board feet, followed by true firs—89 billion, ponderosa and Jeffrey pines—67 billion, redwood—36 billion, and sugar pine—27 billion.

Copies of the report are available from the California Forest and Range Experiment Station, Box 245, Berkeley, Calif.

ASTM Schedules Annual Meeting in Atlantic City

Symposiums on impact testing and speed of testing are included on the program of the 58th annual meeting of the American Society for Testing Materials. The meeting will be held June 26–July 1 in Atlantic City, N. J.

Dates have also been announced for ASTM's 59th and 60th annual meetings. They are June 17–22, 1956, and June 16–21, 1957, both in Atlantic City.

Sawtimber Increase in Louisiana

Louisiana forests are growing 716 million cubic feet of wood annually, while the 1953 cut was only 366 million cubic feet, according to a U. S. Forest Service report. Included is a growth of 2.8 billion board feet of sawtimber, compared to a 1953 sawtimber cut of 1.4 million feet.

The state's forests support about 500 sawmills, 8 pulp mills, and 80 miscellaneous wood-using plants.

Glued Laminated Timbers Setting Architectural Trend

The use of glued laminated timber construction has reached spectacular proportions, according to Leo V. Bodine, executive vice-president of the National Lumber Manufacturers Assoc. Three out of four new churches and thousands of schools, homes, stores, auditoriums, and commercial buildings now exhibit the distinctive architectural forms of "shop grown" timbers.

Mr. Bodine cited four buildings completed within the last two years in which glued laminated construction broke all previous records for timber spans. The longest wood arches ever built frame the roof of the Union College Field House, Schenectady, N. Y. They are 254 feet along the arc and provide a 190 foot clear span. The longest clear span for wood arches is 201½ feet, in the Montana State U. Field House; the longest wood beams, 103 feet, are in a Vancouver, Wash. junior high school; and the longest timber trusses span 248 feet, center to center of supports, in a White Plains, N. Y., hangar.

Wood Products Firms Exhibiting At Furniture Supply Fair

Three wood products and supply companies are among the first suppliers engaging exhibit space at the forthcoming Supply, Equipment and Fabric Fair, sponsored by the National Assoc. of Furniture Manufacturers. They are U. S. Plywood Corp., New York; Wood Conversion Co., St. Paul; and Great Eastern Lumber Co., New York.

The fair, first annual event of its kind, will be held at the Conrad Hilton Hotel in Chicago, August 28–September 1, in conjunction with NAFM's annual convention.

(Continued on page 48-A)

Laminated arches...PENACOLITE®-Bonded

provide strength, safe construction, weather resistance in ultra-modern Florida school buildings

Cocoa High School Auditorium, Cocoa, Florida
Architects: Griffin and Gomon, Daytona Beach, Florida
Contractor: Edward M. Fleming, Miami

■ The beautiful new auditorium and gymnasium at the Cocoa High School in Cocoa, Florida, are good examples of how laminated wooden structural members are being used in modern buildings. The arches and beams in these two school buildings were designed and manufactured by Unit Structures, Inc., of Peshtigo, Wisconsin, and were laminated with "Penacolite" Adhesives, made by Koppers.

These arches give great structural strength without excessive weight. A completely functional design was possible in these buildings because large areas could be spanned (96′ in the auditorium, 128′ in the gym) without sacrificing any of the valuable floor space for supporting posts . . . the base of each arch is *outside* the building.

All the laminating was done with "Penacolite" Adhesives because they form bonds as strong as the wood itself—bonds that can be counted upon to *maintain* their strength despite age, exposure to water and weather, stress and strain, or temperature extremes.

"Penacolite" Adhesives are easy to use too. They cure quickly—in a few hours at room temperature, or in just a few minutes at higher temperatures. For all the facts on "Penacolite" Adhesives and their many uses, write to Koppers for free, illustrated literature.

KOPPERS®

KOPPERS COMPANY, INC.
Chemical Division, Dept. FPJ-65, Koppers Bldg., Pittsburgh 19, Pennsylvania

PENACOLITE® RESORCINOL ADHESIVES

The original waterproof, room-temperature-setting adhesives

Challenges In the Years Ahead

MY FINAL REPORT TO YOU will not dwell on our accomplishments during the past year, but rather on some of our operations which I believe need early strengthening if we are to fulfill the purposes for which the Society was founded.

L. J. Carr

One of my first objectives upon taking office a year ago last May was to visit each of our 13 Sections. I wanted to get the grass-roots sentiments of our members, and determine, if possible, any weaknesses, as well as the strong points of our Society operations. Today, after visiting 12 of our 13 Sections and some 37,000 air miles later, I am happy to report my mission 92.3% accomplished.

The first challenge is our need for greater growth, not just for the sake of more members, but so that FPRS' potential for technical improvement will be recognized and utilized more broadly by the industry. While our membership, especially in the formative years, grew by leaps and bounds to the present 2800, still it has not kept pace with the numbers, prosperity or potential of the industry. To illustrate, I cite from the most recent Census of Manufacturers. In 1950 there were an estimated 33,800 lumber, wood products and furniture manufacturing establishments. Together they constituted the 8th largest employing industry in the U. S., and 11th largest industry in value added by manufacture, some $4 billion annually. Not included in these figures were our huge pulp and paper industry and many of the 60,000 sawmills scattered throughout the land. If but 5% of these 100,000 firms were represented in FPRS by simply *one* $15 voting membership, we would today number over 5,000 members!

Industry Leaders

It is not to the reader, that progressive and faithful member, that I direct this indictment, but rather to the thousands of forest products companies who have failed to avail themselves of membership in this great force for cooperative strength and improvement. I say to these companies, "Step forward and be *counted* among the leaders in your industry!"

My second challenge is directed to our elected leaders and has to do with the quality of our meetings. Many of us well remember the spontaneous enthusiasm which early FPRS meetings all over the country generated. We who participated had high hopes that our Society would early be the potent and moving force for bringing about sorely-needed technological progress. These meetings reflected our high ideals—in the form of high caliber programs, wherein the planners strove to get out the very best contributions in their areas, not always an easy task.

I have since attended many FPRS meetings, some of which have been highly successful, and others near-failures. The reasons can usually be correlated with the amount of effort, "teamwork" of many individuals, and enthusiasm of our leaders. I do not mean to apply the yardstick of "attendance figures" as the measure of success; however, by and large, the more carefully planned the program at every stage, the better the results. Enthusiastic meetings result in new adherents to the Society, while those that are poorly administrated stifle enthusiasm and lose members. And, most important to hundreds of our members who cannot get to meetings, good meetings mean outstanding papers and inspiration in our dynamic FOREST PRODUCTS JOURNAL.

Reaffirm Principles

My final, and perhaps most important, challenge is that each of us, at every level, reaffirm those principles which underlay the founding of our Society—encouragement of closer cooperation between all segments of industry, education and government . . . high standards of product quality . . . and more efficient utilization of our resources.

Our Society places equal emphasis in the fields of research, development, production, utilization and distribution. Too often I sense that we are burdened with simply "putting on a meeting", whereas we should be taking a good look about us to uncover the genuinely new in research—both fundamental and applied—and be making a shirtsleeve effort to get such sponsors to discuss their findings before our groups.

It is high time, too, to ferret out the industrial developments that in many cases have been kept too long "under wraps" to the detriment of industrial progress. And, certainly, we have by no means exhausted the techniques whereby production of lumber and wood products can be increased or improved. To papers on these subjects, whether from research laboratories or industrial sales departments, we have but to apply this standard: "Does it improve our industry? O. K., then, let's hear about it."

Of all of these fields, I believe FPRS' most important progress has been in the promotion of improved utilization. I believe that if we continue here as we have, along with these other challenges, we shall reach that prosperous goal which today is not yet in sight.

The Society has not begun to scratch the surface of its usefulness to the industry in promoting sound marketing practices. We need far more discussion of distribution principles at our meetings, including close scrutiny of those materials which compete with wood-based products, if we are to appeal to the so-called "management" levels of our industry.

These challenges are too big for any one man or limited group of men to meet. They are possible through the unselfish support of all of us.

I want to thank each of our members, our officers in the U. S. and Canada, and the members of my Executive Board for the fine support which you gave me in the past year. That we did make progress we all agree—that far greater progress can be made in the immediate years ahead is the challenge I leave with you, and in the capable hands of your next President.

—L. J. CARR, *President*

IMPORTANT FPRS DATES

June 21–24: 1955 NATIONAL MEETING at Seattle, Wash.

June 29: Pacific Southwest Section Meeting at Los Angeles, Calif.

Aug. 4–5: Inland Empire Section Meeting at Butte, Mont.

Oct. 20–21: Northeast Section Meeting, Prince George Hotel, New York City

Nov. 7–8: Mid-South Section Meeting, Peabody Hotel, Memphis, Tenn.

June 14–17, 1956: FPRS NATIONAL MEETING at Asheville, N. C.

June 24–27, 1957: FPRS NATIONAL MEETING at Buffalo, N. Y.

FPRS COMPANY SUPPORTING MEMBERS

ALABAMA
W. T. Smith Lumber Co., Chapman

ARKANSAS
The Crossett Co., Crossett
Dierks Forests, Inc., Mountain Pine
Southern Lumber Co., Warren

CALIFORNIA
California Redwood Association, San Francisco
L. J. Carr & Co., Sacramento
Crane Mills, Corning
Ivory Pine Co., Dinuba
National Wood Treating Corp., Oroville
Scott Lumber Co., Inc., Burney
Tarter, Webster & Johnson, Stockton
Winton Lumber Co., Martell
E. K. Wood Lumber Co., San Francisco

GEORGIA
Southern Wood Preserving Co., Atlanta

ILLINOIS
The Dean Company, Chicago
General Electric, Illinois Cabinet Plant, Rockford
Greenlee Tool Co., Rockford
Edward Hines Lumber Co., Chicago
Illinois Interior Finish Co., Chicago
Johnson & Carlson, Chicago
Masonite Corp., Chicago
Mattison Machine Works, Rockford
Sherwin–Williams Co., Chicago
Steger Furniture Mfg. Co., Steger
U. S. Industries, Inc., Chicago

INDIANA
The Dunbar Furniture Mfg. Co., Berne
National Homes Corp., Lafayette
The Wood-Worker & Veneers and Plywood, Indianapolis

IOWA
Curtis Co. Inc., Clinton

LOUISIANA
A. J. Hodges Industries, Inc., Shreveport
Louisiana Long Leaf Lumber Co., Fisher

MARYLAND
National Store Fixture Co., Inc., Odenton
J. I. Wells, Salisbury

MASSACHUSETTS
Draper Corp., Hopedale
Heywood–Wakefield Co., Gardner
A. G. Spalding & Bros., Inc., Chicopee

MICHIGAN
Baker Furniture, Inc., Grand Rapids
The Dow Chemical Co., Midland
Everett Piano Co., South Haven
The Lloyd Manufacturing Co., Menominee

MINNESOTA
Mereen–Johnson Machine Co., Minneapolis
Rilco Laminated Products, Inc., St. Paul
Wabash Screen Door Co., Minneapolis

MISSOURI
Monsanto Chemical Co., St. Louis

NEVADA
Vaughn Millwork Co., Reno

NEW YORK
American Defibrator, Inc., New York
Behr-Manning Corp., Troy, N. Y.
Borden Co., New York
Peter Cooper Corps., Gowanda
Georgia Pacific Plywood Co., New York
Oval Wood Dish Corp., Tupper Lake
Reichhold Chemicals, Inc., White Plains
United States Plywood Corp., New York

NORTH CAROLINA
Deluxe Saw & Tool Company, High Point

OHIO
The Baker Wood Preserving Co., Columbus
The Baldwin Piano Co., Cincinnati
Coe Manufacturing Company, Painesville
The Kirk & Blum Mfg. Co., Cincinnati
Moraine Box Company, Dayton

OREGON
Cascades Plywood Corporation, Portland
Forest Fiber Products Co., Forest Grove
Mater Engineering, Corvallis
J. Neils Lumber Co., Portland
Oregon Lumber Co., Baker
West Coast Lumberman's Assn., Portland

PENNSYLVANIA
Blaw–Knox Company, Pittsburgh
Firth Sterling Steel & Carbide Corp., Pittsburgh
Koppers Company, Inc., Pittsburgh
Perkins Glue Co., Lansdale
United States Steel Homes, Inc., Harrisburg
Wood Metals Industries, Inc., Kreamer, Snyder County

SOUTH CAROLINA
Lightsey Brothers, Miley

TENNESSEE
E. L. Bruce Co., Memphis
Chapman Chemical Company, Memphis
Memphis Hardwood Flooring Co., Memphis
Nickey Bros., Inc., Memphis

TEXAS
Wm. Cameron & Co., Inc., Waco
Kirby Lumber Corporation, Houston
Wynnewood Products Co., Jacksonville

VERMONT
Fyles & Rice Co., Inc., Bethel

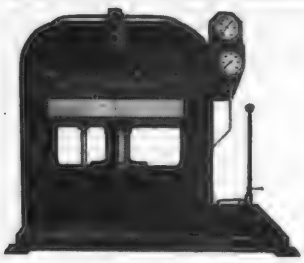
WASHINGTON
American Marietta Co., Seattle
Biles Coleman Lumber Co., Omak
Cascade Lumber Co., Yakima
Deer Park Pine Industry, Inc., Deer Park
Diamond Match Co., Spokane
Douglas Fir Plywood Association, Tacoma
The Long–Bell Lumber Co., Longview
Simpson Logging Co., Shelton
Weyerhaeuser Timber Co., Tacoma

WISCONSIN
The Buckstaff Co., Oshkosh
Harnischfeger Corp., Port Washington
Marathon Corp., Rothschild
Mosinee Paper Mills Co., Mosinee
D. J. Murray Mfg. Co., Wausau
Paine Lumber Co., Oshkosh

ALASKA
Ketchikan Spruce Mills, Ketchikan

CANADA
British Columbia Lbr. Mfrs. Assn., Vancouver, B. C.
Canadian Forest Products Limited, New Westminster, B. C.
Canadian Siempelkamp Ltd., Hamilton, Ont.
Dominion Electrohome Industries, Ltd., Kitchener, Ont.
The Knight Mfg. & Lbr. Co. Ltd., Meaford, Ontario
MacMillan & Bloedel Limited, Nanaimo, B. C.
A. S. Nicholson & Son, Ltd., Burlington, Ont.

Presses

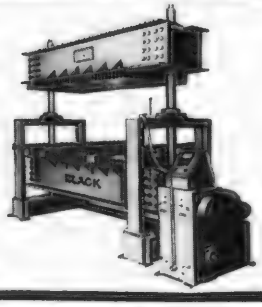


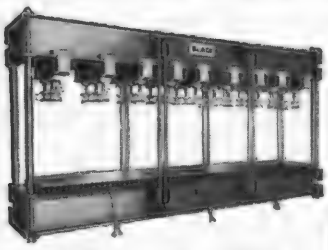
HYDRAULIC PRESSES

Black's hydraulic laminating press is designed for laboratory and experimental work or light production operation. Standard sizes from 1 to 12 or more square feet and pressures up to 100 tons. Now available with heated platens. Variations may be had in size of platens, vertical opening, length of stroke, total pressure applied, heated platens and fast closure arrangements. Write for Bulletin 11-P.

ELECTRIC PRESSES

Black's electric press is fast and efficient on laminating jobs which require moderate pressure, and has proved to be especially popular in the laminating of flush doors and plastic laminates. Here is a high production press at a low initial cost which will give continuous service with an irreducible minimum of maintenance and attention. Write for Bulletin 11-E.





HAND POWERED PRESSES

Black's all steel aircraft model press is stronger and more rigid than conventional presses . . . has wide flange main beams, double corner posts and multiple strain rods. Designed for compact installation requiring no blocking or pit. Offered in a complete range of sizes for every conceivable requirement. Also ten sizes of sectional press units are available. Write for Bulletin 11-G.

"If its gluing equipment—we have it"

write today . . .

THE BLACK BROTHERS CO., INC. 820 9th St., MENDOTA, ILLINOIS

GUEST EDITORIAL

Five Tools for Progress

COL. J. H. JENKINS

Chief, Forest Products Laboratories of Canada, Ottawa, Ontario, Canada

OUR EASTERN CANADIAN SECTION of the Forest Products Research Society is young, only three years old; yet, through our participation in the national activities of our Society, and through our discussions within the Section, we have gained much material benefit.

We have become more aware of mutual problems. We have gained a more thorough understanding of the complexities of the various industries engaged in the manufacture, merchandising, and utilization of wood products. And we have seen or had described to us many examples which prove the value of research.

It is well that this is so because the industrial tempo of our times is very rapid. New discoveries and technological developments result in new materials. Such new materials or new combinations of old materials provide a continually growing source of supply for our industrial needs. Unlike our forefathers who were dependent on a few basic materials, we have access today to a near endless variety of materials to meet our requirements.

These developments have brought many changes and have had their effect on the forest products industries. Many markets formerly served exclusively by wood products have been lost, many others are now shared with competitive materials, and a few have even been added. I need not enumerate the changes that have taken place, nor need I suggest the markets partially or entirely lost to wood, since we are all familiar with developments that have occurred.

Notwithstanding these changes and these lost markets, our forest products industries have continued to expand. It is true that during recent years there has been a constantly increasing overall demand for forest products and that—assessed from many viewpoints—there is every indication that possible markets for wood products will continue to grow in volume.

Yet a more searching look provides another picture. It shows that as a whole we have not kept pace with our expanding national development. Had wood been able to retain its former ascendancy in the building materials field, our present total production would fall far short of the required supply.

One example taken from the Stanford report shows that lumber consumption in the U. S. has declined steadily from 18,900 bd. ft. per dwelling unit in 1920 to 10,520 bd. ft. in 1953, a 44 per cent drop due principally to architectural changes and the trend to smaller families and one family dwelling units—indeed a difficult marketing condition to alter. This same report also showed that between 1950 and 1953 lumber in house construction fell off more rapidly in these three years than it had in the previous thirty years, due largely to the growing popularity of slab-type construction. This situation is not confined only to lumber as other wood products are meeting an ever wider and more intensive competition from a large variety of other materials.

For a country like Canada with its abundant forests, where the economic and industrial outlook gives evidence of continued buoyant trade, and where population is certain to show large increases, I am convinced that with concerted effort the forest products industries can substantially build up present markets and gain new ones.

Reaping Full Benefit of Opportunities

Modern progress has not by-passed the forest products industries, and in recent years there have been many important developments. Manufacturing and processing techniques are improving with our growing technological knowledge. However, in order to reap full benefit from the opportunities that lie ahead, it is incumbent upon us to avail ourselves fully of knowledge and other means at our disposal. Briefly then, I believe we should:

(1) make full use of the large amount of technical data now available and that will continue to become available in the future as a result of long-term research undertaken by Government and other institutions;
(2) intensify industrial research on improved manufacturing techniques and in the development of new processes and products;
(3) analyze closely industrial trends and products in relation to consumer demand;
(4) keep under constant review every utilization practice to reduce waste to the very minimum;
(5) and not least, continue our participation in societies such as F.P.R.S. so that, combining our knowledge, we may better understand our problems and more effectively plan our future.

The Author: Col. J. H. Jenkins received a degree in Forest Engineering from the University of British Columbia in 1923. He was in charge of seasoning and sawmilling research at the Vancouver FPL from 1924–39. In 1946 he was appointed Assistant Superintendent of the Ottawa Laboratory, and in January 1950 became Chief of the Forest Products Laboratories of Canada. Col. Jenkins is a veteran of World Wars I and II and received numerous military citations. He has served as Vice-Chairman, Chairman, and Past Chairman of the Eastern Canadian Section, F.P.R.S.

FPRS

THIS BEAUTIFUL GOLD FINISH LAPEL PIN IS YOURS FOR ONLY 75¢

Send for Your FPRS Lapel Pin And Membership Certificate Now

Buy and wear an FPRS lapel pin. It will identify you as an active supporter of wood industry research and progress. The attractive green and gold pins are available for 75 cents each. For an additional 25 cents, you can receive 8 x 10 framable membership certificate (right). Send your order to Executive Secretary, Box 2010, University Station, Madison 5, Wis.

Forest Products Research Society
MEMBERSHIP CERTIFICATE
This is to certify that

Get Both bearing features

fully enclosed and protected

The bearing cap is held tightly in place against the inner face of the bearing enclosure. This cap, with its close running clearances, keeps grease from the interior of the motor . . . retains an ample supply within the bearing enclosure . . . protects the grease and the bearing against contamination from dirt and moisture.

At the outer side of the bearing, double labyrinth seals keep grease in, also keep dirt out. What's more, large grease reservoirs act as additional dirt traps.

. . . yet easy to grease

You can lubricate the bearings without dismantling the motor. Pipe-tapped holes in the bearing housings at two points provide both means for inserting new grease and a means of flushing out old grease.

Look for the extra bolts on the end housing . . . the sign of greater value. Ask your Allis-Chalmers representative or Authorized Distributor to show you a cutaway section of this maintenance-cutting design. Or write Allis-Chalmers, Milwaukee 1, Wisconsin, for Bulletin 51B6210.

A-4608

ALLIS-CHALMERS

Fiber Products as a Factor in Utilization[1]

EDWARD G. LOCKE and KENNETH G. JOHNSON

Forest Products Laboratory,[2] Forest Service, U. S. Department of Agriculture

New fiber products, results of research and development, are causing dramatic changes in the forest products field. Their combination with other wood products is opening new markets and improving competitive position of forest products industry.

THE FASTEST GROWING SEGMENT of the forest products industry today is the fiber products industry.

Paper consumption in the United States increased from about 9 million tons in 1929 to about 17.5 million tons in 1953. By 1975 it is expected to be about 28 million tons (21).

Consumption of paperboard and containerboard has more than tripled during the past 25 years, while consumption of building board has grown more than tenfold. The greatest increase has been in the use of hardboard; about 16 times as much hardboard was used in 1953 as in 1929. Insulating board showed a 700 per cent increase during the same period (21).

One of the main reasons for the regular, rapid, and long-time increase in the use of fiber for products is its suitability for a multitude of uses. The fiber industries take the well-alined fibers that exist in wood and through chemical and mechanical processes jumble them up and make them over into new materials. These materials can have high strength and uniformity and can be made in large sheets, thick or thin, rigid or flexible. The fiber is the building block, and the variety of properties that can be achieved with it is great indeed.

Paper, for example, can readily be modified by relatively simple papermaking operations. Early papermakers, without benefit of scientific knowledge, could make paper that was hard or soft, porous or nonporous, dense or bulky, simply by varying the amount of mechanical action in the beater, or by changing the pressure on the wet sheet in the press.

These early papers were fiber and little else. Today a paper product that contains only fiber is the exception rather than the rule. In recent years we have seen foils of lead, tin, and aluminum bonded to paper with asphalt, resins, or rubber latexes; impregnants and beater additives of resins, latexes, and waxes; coatings of resins, lacquers, starch, or casein, with or without fillers of clay, minerals, or metals (2).

Fiber Products Increase

During the past 20 years fiber products have taken a prominent place in building construction (18). There has been a great increase in the use of sheathing papers, roofing papers, flooring and roofing felts, and roof shingles. Sheathing and building boards, fiber insulation blankets, and fibrous softboards are now widely used. New uses have been found for hardboards and boards made of shavings, chips, and particles.

Fiber containers are gaining popularity for shipping citrus fruit and leafy vegetables. The containers used for lemons are treated with a fungicide to retard mold. Fiber containers are especially suitable for use with the vacuum cooling process recently developed for leafy vegetables like lettuce. The vegetable can be picked, sorted, graded, packed in fiberboard boxes, and the boxes closed right in the field (2).

Obviously the tremendous growth of the fiber products industry has had an impact on other forest products industries. The fiberboard box is slowly replacing the wooden box for shipping many commodities. Insulating sheathing is taking the place of lumber and plywood sheathing on many new homes. Hardboards and particle boards are taking their share of the lumber and plywood market. Paper honeycomb cores in wall panels may some day take the place of studs. There is every reason to believe that fiber products will invade more and more of the markets now held by lumber.

But the picture is not all dark for the lumber producer. In spite of competition from fiber products and from metals, plastics, and asbestos, total lumber consumption is expected to increase moderately from 41.3 billion board feet in 1953 to 44.6 billion board feet in 1975 (21).

The point for lumber producers to remember is this: these fiber products are made of wood, and a lumber producer is, after all, a wood processor. These new fiber products may, indeed, prove to be a godsend. By cooperating with and encouraging the development of fiber products industries, a lumber producer may be able to reduce his costs, improve his timber stand, and, in some cases, improve his product (3).

Integrated Operations

The kind of cooperation I have in mind begins with the integration of woods operations (7, 8). The cull trees, the broken sections, tops, limbs, and thinnings that are a part of the yield of every forest will never make such products as lumber, cooperage, veneer, or poles, but they can be converted to valuable products by the fiber industries.

The tools of harvesting have changed in recent years, but the essentials remain the same; we must cut a tree, allow it to fall, cut it to pieces, and collect and transport those pieces by some means. The more value we can get out of these operations, the lower our raw material costs will be.

In an integrated operation, part of the cost of growing mature trees of high value can be defrayed by the earlier harvesting of younger, low-cost material. A good job of harvesting, which would include thinning and removing cull trees, can increase the value of the forest by speeding up the rotation and the production of a new crop. It can, in fact, about double the production per acre. It can also reduce the danger of fire and thus lower fire-protection costs.

A less tangible, but no less important value of integrated operations lies in the ecological effects of management practices. An integrated operation, be-

[1] Presented at a meeting of the Inland Empire Section, FPRS, Jan. 21, 1955, in Yakima, Wash.

[2] Maintained at Madison, Wis., in cooperation with the University of Wisconsin.

The Authors: Dr. Edward G. Locke, Chief of Division of Derived Products, holds B.S. in chemical engineering from Oregon State College, Ph.D. in organic chemistry from Ohio State University. He formerly was Chief of Forest Utilization Service at Pacific Northwest Forest and Range Experiment Station. Chairman of the FPRS Publications Committee, Dr. Locke is a past national president of the Society.

Kenneth G. Johnson, publication writer, received B.S. in chemistry and M.S. in journalism U. of Wisconsin. He formerly taught journalism at Michigan State College and served as editor at Central States Forest Experiment Station.

cause it can afford to take or leave any part of the forest crop, can determine the composition of the future forest; in this way it promotes the lowest-cost and most efficient silviculture (20).

We must not overlook the fact, however, that each component of an integrated operation has a minimum economic size. The forest must therefore be sufficient to supply each component with enough raw material to operate at least a minimum-size plant.

Increased Supplies

Portable chippers that can be used in the woods are a recent development that may increase the supply of wood for the fiber industries. Some kraft pulp and structural fiberboard is now being made from chips prepared in the woods. The advantage of this operation lies in the fact that trees of smaller diameter can be handled and a higher yield of chips obtained per acre. A company in Wisconsin has found by actual woods experience with hardwoods that by reducing top diameters from 4 inches to 1 inch it has been able to salvage an additional 4 cords of wood for every 6 cords that would normally be produced (5).

Along with chippers, new devices for cleaning pulp may help bring about more complete harvesting of pulpwood. It might be possible, for instance, to use portable chippers in the woods to chip even limbs and branches without removing the bark. Some of the bark could be removed after chipping by an air separation method, and the wood could be cooked by an alkaline process. If the pulp were to be used for paper, centrifugal cleaners in the pulp mill, the bleach plant, and the paper mill could take out the rest of the bark.

The cooperation that begins in the woods should continue in the processing plant.

As long as we make square boards from round trees we will continue to create material that is of little or no value to the lumber producer but of great value to the fiber industry. Slabs and edgings are excellent sources of fiber, and even sawdust can be used in making some fiber products.

At present the most profitable way to use slabs and edgings is to convert them into chips and to process them into pulp (6). Both softwoods and hardwoods can be used. Each year more barkers and chippers are being used at sawmills and veneer mills to produce pulpable material. In the Pacific Northwest, more than 100 chipping plants have been built at sawmills and plywood plants.

Each year sawmill barkers are producing more bark in a form suitable for further processing. Already the bark of several species is being utilized in small quantities for such products as mulches, insulating materials, resin adhesive extenders, and oil-well drilling compounds. Research is continuing in an effort to develop new processes and new bark products.

Five processes are used commercially in making wood pulp (8). One is the mechanical or groundwood process in which the wood in the form of bolts is reduced to pulp on a grindstone. Softwoods are preferred and the result is a low-cost, low-strength, high-yield pulp that is usually blended with other pulps having higher strength characteristics.

Three processes—the sulfite, sulfate, and soda—depend upon chemical reagents to dissolve essentially all the lignin and leave the cellulose fibers in a fairly pure state. Nonresinous softwoods are preferred for the sulfite process, although many hardwood species can be used. The sulfite process is the most suitable for most dissolving pulps. The majority of viscose pulps and all acetate grade pulps are made by the sulfite process.

Flexible Process

The sulfate process is an alkaline one and is the most flexible with regard to species and end use. Resinous as well as nonresinous woods may be used. Chip quality and the amount of bark are not as critical as they are for sulfite pulp. If an acid prehydrolysis is used, chemical dissolving pulps can be produced by the sulfate process. The prehydrolysis releases pentoses that can be processed into furfural, an intermediate organic chemical much in demand for the manufacture of nylon.

Most species can be pulped satisfactorily by the soda process, although hardwoods are usually used. In many ways it is similar to the sulfate process, but yields are about 10 per cent lower.

In the fifth process, the semichemical, only a part of the lignin is removed by chemical means, and pulping is completed by mechanical refining. A variety of chemical solutions may be used, or the chips may simply be softened by steaming. The yield of pulp is relatively high. The semichemical process is now used in the production of corrugating board stock, lower grade wrappings, roofing felt, insulating board, and hardboard. Pulps properly prepared by the neutral sulfite semichemical process are suitable for bleaching and may be used in making newsprint, food board, glassine, tissues, and bond and book papers.

An interesting new variation of the semichemical process is the so-called cold soda process developed at the Forest Products Laboratory. The pulp is made by simply steeping chips in a solution of caustic soda at room temperature, then refining them in a disk mill. The yield is about 90 per cent, which is close to the yield from the groundwood process. Because no pressure is used and the reaction time with some species is short, it appears possible to produce cold soda pulps by a continuous process.

The Inland Empire Region is in a favorable position to take advantage of the possibilities offered by integration. The species that are abundant in this region are the preferred pulping species—the long-fibered softwoods. The sawmill and veneer mill residues are concentrated enough to interest the fiber products industries.

Engelmann spruce is highly regarded for papermaking because of its relatively light color, its long slender fibers, and its ease of pulping (16). It can be pulped easily by the sulfite, sulfate, and groundwood processes and made into a wide variety of papers.

Ponderosa pine is very similar to jack pine, an accepted pulping species, in its sulfate-pulping characteristics and in the strength of the pulps produced (13). It actually requires less chemical and produces less screenings than jack pine.

Good-quality pulps can be made from lodgepole pine by the groundwood, sulfite, or sulfate processes (10). Even insect-killed wood with 28 per cent advanced decay pulped satisfactorily in experiments at the Forest Products Laboratory.

Engelmann spruce and lodgepole pine are so desirable as pulping material that they are shipped from the Rocky Mountain area to pulp mills in Wisconsin.

Douglas-fir (1, 11, 12, 14, 15, 17) has already been proven as a pulp species in many mills in the Pacific Northwest. By the kraft process a pulp of unusually high tearing strength is produced, but with low bursting strength. Lodgepole pine kraft pulp has the opposite properties so that the two species are complementary to each other. Blends of these two pulps produce a high-grade product.

Hardwood Pulping

The hardwoods in this region will also make suitable pulps, particularly by the neutral sulfite semichemical process and possibly by the new cold soda process (9). These pulps would be useful for blending with the long-fibered softwoods to make a wide variety of papers. Experiments at the Laboratory have shown that neutral sulfite semichemical pulps can be blended with softwood pulps to make newsprint, folding food boards, milk containers, and bond papers.

The Laboratory is frequently asked about the possibilities of developing less expensive pulp and paper mills or processes. Capital costs are indeed high in this industry. We believe, however, that new engineering developments are coming along that will permit smaller minimum sizes for pulp mills. Some of the newer processes (both continuous

and batch processes) inherently require less equipment and appear better suited to small-scale operations. Hardboard, insulation board, and corrugating medium are now being produced by continuous processes at some plants.

Residues of most species can be processed into hardboard. During the past 6 years the productive capacity for hardboard in the United States has more than doubled, and still more plants are being planned. It is made from chips that have been fiberized, formed into mats, and pressed into flat sheets. Resin binders are often used to strengthen the product. Much of this material goes to the industrial market where it is cut up and fabricated into other products.

Particle boards are a new class of boards produced from wood residues (6). The wood is usually reduced to the proper size in a hammer mill, resin is added, the moisture content is carefully controlled, and the material is pressed into sheets. The Forest Products Laboratory is now evaluating the effect of particle size and shape on the properties of such boards. They can be surfaced with paper, specially prepared flakes of wood, veneer, plywood, or even hardboards. I believe we have seen only the beginning of this type of product.

The economic advantage of selling chips will be apparent to any lumber producer or veneer mill operator within shipping distance of a fiber industry. The fiber industries, too, have found that in some areas it is more economical to buy chips than to produce pulpwood. At least one pulp mill in the Pacific Northwest operates entirely on chips from lumber and veneer mills. Many mills throughout the country are obtaining more and more of their chip requirements from this source.

Industry Integration

In recent years a new type of integration has developed in the forest products industries; there is now a fair amount of integration of fiber products with other kinds of wood products in the manufacture of a whole range of composite materials.

The paper honeycomb structural panel is a good example of a composite product (19). Paper, in the form of a honeycomb core, is combined with strong and stiff facings of wood, plywood, hardboard, or metal to form a permanent exterior structural building material. The paper is resin impregnated and bonded to the facings by waterproof glues. The panels produced in this way combine the functions of the studs, joists, nails, and insulation. They can be used for house panels, movable partitions, truck bodies, aircraft and boat parts, furniture, and many other applications.

Another product involving paper honeycomb being tried at the Forest Products Laboratory is an acoustical ceiling panel (18). The panel is made of thin facings of white-pocket Douglas-fir veneer glued to a 1-inch thick paper honeycomb treated with resin to strengthen and waterproof it. The white pocket is not only decorative, it permits sound waves to enter the panel. To keep the sound from bouncing straight out again, the honeycomb is made with flutes diagonal to the facings. After tests at the Bureau of Standards showed that the material had reasonably good acoustical properties, it was installed on the ceilings of two offices at the Laboratory.

Strong papers treated with phenolic resin can perform structurally much as wood does. They are strong and stiff when dry and not much weaker when wet. When such papers are bonded to veneer, they reduce the expansion of the veneer and produce a stiff sheet material that is especially useful for boxes. When they are bonded to certain kinds of plywood, they obscure minor defects, patches, and checks, and provide a better base for painting. In both cases they can be used to upgrade material that might otherwise be unmarketable.

Upgrading Lumber

More recently we have tried to put overlays on low-grade lumber (4, 22, 23). Actually, the first tests of this type at the Laboratory were conducted in 1932, but until modern resins were developed the process showed little promise. The object of a paper overlay for lumber is of course, to upgrade low-grade boards. In this case, the defects are large and varied and, because thick pieces of wood exert more force as they shrink and swell, the problem is more difficult than with veneer or plywood.

The overlaid lumber used in most of the tests at the Laboratory consisted of No. 2 Common white pine, ¾ inch thick, overlaid on both sides with a resin-impregnated kraft sheet about 18 thousandths of an inch thick. Open defects such as knotholes were either eliminated or plugged. The overlay sheet was made with about 20 per cent of water-dispersible phenolic resin added at the beater, and the resin was fully cured before the paper was applied to the lumber. The overlay was bonded to the lumber base in a cold press using a typical room-temperature-setting, acid-catalyzed phenolic adhesive.

Some of this paper-overlaid lumber was made up in the form of siding and exposed on the side of one of the Laboratory buildings along with some redwood siding of the same dimensions. Both were painted, and after a year of exposure it is difficult to tell one from the other. Both look good.

Paper overlays can play a double role in integrated operations. First, they can be made from tops, limbs, thinnings, low-quality trees, or sawmill and veneer mill residues. Second, they can upgrade low-grade lumber, veneer, and plywood to produce quality products. In both ways they contribute much to good forestry by making low-quality trees and little-used species worth the cost of getting them out of the way so that better trees can grow to maturity.

New Uses for Paper

Once we recognize that paper can be used as a structural material, it becomes easy to conceive new uses for it. A vented siding combining a paper honeycomb core and paper overlaid veneer facings is being service-tested at the Laboratory. The idea of this siding is that the tube-like cells in the honeycomb core will help to ventilate the wall, permitting entrapped moisture to escape and thereby avoiding some types of paint blistering and other moisture problems.

Among the other composite forest products that show promise or are already being produced are hardboard-faced lumber, plywood, and particle board; plywood- and hardboard-faced honeycomb; veneer-faced lumber and hardboard; and plywood faced with a paper plastic and backed with hardboard. If we add the modified woods, impreg and compreg, to our list, several more combinations are possible. Each useful combination opens up new markets and improves the competitive position of the forest products industries.

All of these new products have one thing in common: they are the results of research and development. Research men looked at the wood fiber and saw in it possibilities for a multitude of products. Their discoveries have made dramatic changes in the forest products industries. This industry of yours is not a static industry; it is constantly changing. There is no room in it for those who are content to rest on their laurels, nor is there room for the "lone wolf" type of operator. The greatest good for the entire industry will come from close cooperation among lumber, veneer, and fiber products manufacturers, research organizations, and all other phases of the forest products industries.

Literature Cited

1. Bray, W., and Martin, J. 1947. Sulphate pulping of Douglas-fir, Western hemlock, Pacific silver fir, and Western red cedar logging and sawmill waste. Paper Trade Journal 125(16):40–46.
2. Chidester, G. H. 1953. New and improved paper products. Paper Industry 35(9):1002–1005.
3. Hall, J. A. 1954. Economic aspects of integrating pulp and paper industries

with other forest industries. Presented at the Latin American Meeting of Experts on the Pulp and Paper Industry, Buenos Aires, October 20, 1954.
4. Hall, J. A. 1954. Paper and wood—a new team. Paper Industry 35(11): 1269-1272 The Timberman 55(6): 124-127.
5. Koepp, W. H. 1953. Chips from logging operations. Pulpwood Annual 1953. pp. 24–28.
6. Locke, Edward G. 1954. Chemical utilization and forest management. Journal of the Forest Products Research Society 4(1):10–13.
7. Locke, Edward G. 1949. Patterns for integrated complete wood utilization. The Timberman 50(11):44–47, 92–93.
8. Locke, Edward G., and Johnson, Kenneth G. 1954. Wood resources. Ind. Eng. Chem. 46(3):478–83.
9. McGovern, J. N. 1953. Pulp and paper: tools for hardwood utilization. J. Forest Products Research Society 3(5):61–67.
10. McGovern, J. N. 1951. Pulping of lodgepole pine. U. S. Forest Products Laboratory Report No. R1792.
11. McGovern, J. N., Keller, E. L., Martin, J. S., and Kingsbury, R. M. 1951. Semi-chemical pulping characteristics of Pacific coast red alder, Douglas-fir, Western redcedar, and Western hemlock. U. S. Forest Products Laboratory Report No. R1912.
12. Martin, J. S. 1949. Sulfate pulping of logging and sawmill wastes of old-growth Douglas-fir and of certain associated species. U. S. Forest Products Laboratory Report No. R1747.
13. Martin, J. S. 1951. Sulfate pulping of ponderosa pine thinnings. U. S. Forest Products Laboratory Report No. R1909.
14. Martin, J. S., Kingsbury, R. M., McGovern, J. N., and Lloyd, R. A. 1953. Utilization of white-pocket Douglas-fir: pulping and chemical conversion. U. S. Forest Products Laboratory Report No. 1961.
15. Paul, Benson H. 1947. Thinnings from second-growth Douglas-fir for pulp. U. S. Forest Products Laboratory Report No. R1689.
16. Schafer, E. R. 1953. Engelmann spruce for pulp and paper products. U. S. Forest Products Laboratory Report No. R1944–2.
17. Schwartz, Sidney L. 1950. Insulating board from Douglas-fir and alder. Paper Industry 32(9):974–976.
18. Seidl, Robert J. 1954. Paper and fiber products in construction. Chapter in the Ninth Annual Short Course in Residential Construction. The Small Homes Council, University of Illinois, Urbana.
19. Seidl, Robert J. 1952. Paper-honeycomb cores for structural sandwich panels. Paper Industry 34(9):1112–1115. J. Forest Products Research Society 2(4):13–22. U. S. Forest Products Laboratory Report No. R1918.
20. Seidl, Robert J. 1954. Relation of utilization to forest management. In Papers Presented at the Fiftieth Anniversary Celebration, Forestry Department, University of Maine, Orono, Maine.
21. Stanford Research Institute. 1954. America's demand for wood 1929–1975. Weyerhaeuser Timber Co., Tacoma, Wash.
22. U. S. Forest Products Laboratory. 1954. What's new at the forest products laboratory in the field of wood, paper, resin combinations? J. Forest Products Research Society 4(2):22–29.
23. Heebink, B. G., Seidl, R. J., Laughnan, D. F., and Blomquist, R. F. 1955. Some potentialities of overlaid lumber. Forest Products Journal V (2):97.

Tests of a Portable Wood Chipper[1]

J. L. AREND, R. N. SMITH, and R. A. RALSTON

Lake States Forest Experiment Station,[2] St. Paul, Minn.

Discusses 8-knife and 12-knife portable wood chippers, types of wood material chipped, average wood chip production rates and costs obtained, characteristics of the chips produced, and general performance of the machine tested.

IN VIEW OF THE POTENTIAL USES for portable wood chippers in forestry and allied fields, a series of performance tests was made in Lower Michigan during 1953 to obtain data for one type of chipper under typical field conditions. The chipper was designed to chip brush, branches, or tops up to 6-inch diameter. A basic model, with and without several modifications to increase production, was tested.

The machine consists of a two-wheel trailer, power unit, and chipper unit. Power is transmitted from the 4-cylinder, air-cooled engine through a clutch and V-belt drive to the cylindrical chipper. Chips are produced by 8 cutting knives (12 on the modified model) mounted on the base of the cylinder and three stationary cutting bars under the cylinder.

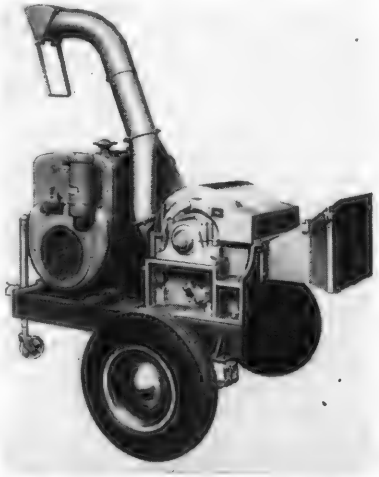


Fig. 1.—Portable wood chipper tested.

Air currents carry the chips up and out of a discharge pipe. The end of the pipe is 9 feet above the ground over the trailer hitch. This height may be increased by insertion of sections. The angle of discharge allows use of a truck with high-sided box; and the end of the discharge pipe may be turned 90 degrees in either direction, enabling side loading or discharge to ground. An adjustable deflector permits blowing of chips between 5 to 50 feet from chipper.

Tests were made on logging and brush disposal operations using red and white oak, aspen, jack pine, and apple orchard trimmings. Wood material for oak and aspen tests was sorted into 3 diameter classes, measured at the large end: less than 1-inch diameter; 1 to 4 inches diameter; and 4 to 6 inches diameter. Two size classes were used for jack and red pine: branches less than 1-inch diameter; stems 1 to 6 inches diameter. The length of material varied from 3 to 12 feet. A few longer aspen stems to 30 feet were chipped. Most of the wood was cut during the dormant season.

The volume of chips produced during each test was measured in a specially constructed box. Each test produced 100 to 150 cubic feet of chips. Trials were repeated twice, and in some instances, three times. Samples were

[1] Digest of Station Paper 30, Lake States Forest Experiment Station, Forest Service, U. S. Department of Agriculture.

[2] Maintained at St. Paul, Minn., in cooperation with the University of Minnesota.

The Authors: J. L. Arend received B.S., B.S.F., and M.F. degrees from U. of Michigan. He also took post graduate work at Ecole Nationale des Eaux et Forests, Nancy, France. Arend has worked in forest management research since 1937, is now forester in charge, Lower Peninsula Forest Research Center, E. Lansing, Mich.

Richard N. Smith holds B.F. from U. of Massachusetts, worked on Superior and Chippewa National Forests before transfer to Lake States Station in 1953. He is now working on forest survey in upper Michigan.

Robert A. Ralston received B.S.F. from Colorado A. & M., M.F. from U. of Michigan. He has worked in forest management research in Minnesota and lower Michigan, is now forester in charge, Northern Lakes Research Center, Wausau, Wis.

caught in three 1-cubic-foot boxes located in the bed of the truck. As the truck was unloaded the boxes were removed, leveled, and weighed. Later oven dry weights were determined.

Other information collected during the tests included:

1) Average time required to move chipper from one pile of brush to another.
2) Approximate ratio of solid wood to wood chip volume.
3) Approximate ratio of piled brush to wood chip volume.
4) Estimate of average volume of wood available in tops of aspen and jack pine left in woods after pulpwood logging.
5) Amount of settling of chips in truck box after 1 to 4 miles of driving.

Production Rates

Production rates varied considerably according to species and diameter class of wood chipped, and model of machine used (Tables 1, 2). Rates are presented in cubic feet of chips per hour rather than tons or pounds because weight of chips per unit volume for a given species varies, depending on the moisture content of unchipped wood. Rates are based on total chipping time, including delays, with two men feeding the machine. The rates are not maximum for the size class of material being chipped by this machine; they are representative of operations where a supply of piled wood is available.

With the original machine, chip production increased with diameter class of material for all species except freshly cut jack pine limbs with foliage (Table 1). The largest increase occurred on material 1 to 4 inches in diameter. There is more solid wood in larger sticks than in an armload of brush; consequently the chipper received a larger volume of solid wood per cylinder revolution. Also, there was more delay feeding brush which was short and crooked.

Production rates with the modified machine were higher for material up to 4 inches and less for material exceeding this diameter than those with the original machine (Table 2). For oak, production decreased as diameter increased. Opposite results were obtained with aspen.

Increases resulted primarily from improved mechanical features. The number of cutting knives was increased from 8 to 12. Cylinder speed was increased from 1,500 to 2,000 rpm. A larger feed hopper permitted larger armfuls of brush to be fed into the machine. Lowering the feed bed increased the cutting angle, thereby pulling in the material more rapidly.

Fig. 2.—Samples of aspen wood chips obtained with the portable chipper tested from material less than 1, 1 to 4, and 4 to 6 inches in diameter.

With material over 4 inches, design modifications resulted in lower production. The 12-knife machine was easily stalled by 4-inch and larger wood.

Straightness of Material Chipped

Straightness of the wood affects production rates (Tables 1, 2). The hourly rate for straight lengths of oak brush with the modified machine was nearly four times that of the original, whereas production was not even doubled with crooked aspen brush used in both tests. Normally, wood chip production from aspen should exceed that of oak since resistance to cutting strength of oak is higher.

Wood material 1 inch and larger in diameter chipped during these tests was similar in straightness and length. These characteristics varied in material below 1-inch diameter. Oak of this diameter was principally from tops cut during the dormant season. Sticks were 3 to 6 feet and very crooked.

Production averaged 77 cubic feet of wood chips per hour from this material with the original machine (Table 1). The oak chipped in the modified machine was from roadside brush, 5 to 12 feet long, fairly straight. Production averaged 286 cubic feet per hour.

Dryness of Wood Chipped

Dryness had little effect on production with the modified machine, the same production being obtained from

Fig. 3.—Size classes of screened wood chips obtained from aspen sticks 1 to 4 inches in diameter with two models of chipper tested.

Table 1.—VOLUME[1] IN CUBIC FEET OF WOOD CHIPS PRODUCED PER HOUR[2] WITH CHIPPER HAVING EIGHT KNIVES

Species	When diameter class is:[3] 0–1 inches	1–4 inches	4–6 inches	Average, 0–6 inches
Oak	77	137	169	128
Aspen	83	216	241	180
Jack pine	[4]232	[5]183	---	---

[1]Settled volume of chips after load had been transported 1 to 4 miles.
[2]Production rates are based on chipping time from the start to the end of each test with two men feeding the machine. All operational delays that occurred while feeding the machine with prepared wood are included.
[3]Random lengths varying generally from about 3 to 12 feet.
[4]Jack pine limbs of this diameter class include the foliage, which increased the production per hour considerably compared to hardwood branches of similar size with no foliage.
[5]Diameter class was actually 1 to 6 inches with no foliage attached.

Table 2.—VOLUME[1] IN CUBIC FEET OF WOOD CHIPS PRODUCED PER HOUR[2] WITH CHIPPER HAVING 12 KNIVES

Species	When diameter class is:[3] 0–1 inches	1–4 inches	4–6 inches	Average, 0–6 inches
Oak	[4]286	170	128	195
Aspen	141	227	197	188
Red pine	[4]269	239	---	254

[1]Settled volume of chips after load had been transported 1 to 4 miles.
[2]Production rates are based on chipping time from the start to the end of each test with two men feeding the machine. All operational delays that occurred while feeding the machine with prepared wood, including delays due to unavoidable stalling, are included.
[3]Random lengths varying from 3 to 12 feet.
[4]Freshly cut branches with attached foliage still green.

Fig. 4.—Pile of oak brush at left was reduced in 20 minutes to amount of chips at right. An average of 15 cu. ft. of piled brush reduced to 1 cu. ft. of wood chips in the study.

fresh cut oak brush as from 5-month-old material. Aspen brush was used in the tests with both machines. Production from aspen brush under 1 inch diameter was 83 cubic feet per hour with the original machine compared with 141 cubic feet with the modified machine. Average chip production with the modified machine for brush material less than 1 inch was nearly double that of the original chipper.

Effects of Green Foliage

The amount of green foliage on the material chipped had a marked influence on production rates. Apparent rates from pine branches with foliage were higher with both chippers than those obtained from larger size material of the same species without foliage. This increase was due to fragments of needles and twigs adding to the volume and green weight. Oven-dry weight was relatively low (Table 6).

Volume Ratio of Solid Wood to Wood Chips

The diameters of both ends and the lengths of sticks of oak, aspen, and jack pine were measured and the cubic volumes computed before they were chipped. The average volume measured per cubic foot of solid wood ranged from 2.3 for jack pine and oak to 2.5 cubic feet for aspen. It appears that approximately 200 cubic feet of chips can be obtained from a standard cord containing 80 cubic feet of solid wood.

Volume Ratio of Piled Brush to Chips

Whole piles of oak and aspen brush of material less than 1-inch diameter were measured prior to chipping. It was found that 1 cubic foot of chips could be produced from 13 to 20 cubic feet of piled brush (Table 3).

Table 3.—VOLUME OF PILED BRUSH[1] REQUIRED TO PRODUCE 1 CUBIC FOOT OF CHIPS

Species	Character of brush	Volume per cubic foot of chips
		Cubic feet
Oak	From tops of sawlog size trees	20
Oak	Saplings from right of way	14
Oak	Saplings from right of way	13
Aspen	From pulpwood tops	13
	Average	15

[1] Carefully piled and compacted by its own weight.

Character of Chips Produced

Although the chips produced with the 12-knife chipper were larger than those with the 8-knife chipper, they were less uniform in size. For example, three-fourths of the chips from the latter passed through a ¼-inch screen and the remainder through a ½-inch screen.

The chips from the 12-knife chipper were more evenly distributed among the three size classes. Two-thirds were too large to pass ¼ inch; one-fifth too large to pass through a ½-inch screen. All chips from both chippers passed through a 1-inch screen.

A test by the U. S. Forest Products Laboratory of the aspen chips from the original machine showed that the percentage of chips passable through a 1–4-inch screen was higher than that of chips from a disc-type chipper. A pulping and papermaking test showed that aspen chips produced by this chipper could be used commercially. Wood chips from the modified chipper have not been so tested.

Table 4.—SIZE CLASSES OF WOOD CHIPS PRODUCED

Size of chips[1] (inches)	Knives on cylinder	Chips produced from —				All species and sizes
		Aspen		Oak		
		1–4	4–6	1–4	4–6	
		Number				
0 – 1/4	8	65	71	65	82	72
	12	25	36	34	39	33
1/4 – 1/2	8	29	25	31	13	24
	12	44	42	50	44	45
1/2 – 1	8	6	4	4	5	5
	12	31	22	16	17	22
		Percent of total				

[1] Based on percentage of 2-pound samples of wood chips which passed through screens with mesh indicated.

Chips of both chippers from small brush, less than 1-inch diameter, were higher in bark than those from wood material exceeding 1-inch diameter. This held true of all species. Brush and small limbs tended to splinter somewhat and occasionally 3 to 4 inch sections of twigs passed through intact.

Chips obtained from material in the 1- to 4- and 4- to 6-inch diameter classes were more uniform in size and shape than those from smaller material. It was observed with the two larger diameter classes of material that much of the bark was broken off during chipping.

With either chipper, the size of chip may be varied by changing the amount of projection of the knives from the cylinder and varying the clearance. Reduction in projection or clearance, or both, reduces the size of chips, thus enabling production, within limits, of chips of varying size classes.

Weight of Chips

Field Weight: Weight of green oak chips averaged 22 to 24 pounds per cubic foot compared to 12 to 21 pounds for aspen (Tables 5, 6). Green jack pine chips from the main stem of trees cut during the dormant season averaged 30 pounds per cubic foot compared to chips from limbs with foliage of 18 pounds. Chips from red pine with or without foliage, cut during the growing season, weighed 21 pounds per cubic foot.

Table 5.—WEIGHT AND MOISTURE CONTENT OF WOOD CHIPS PRODUCED DURING DORMANT SEASON WITH 8-KNIFE MACHINE, BY SPECIES AND DIAMETER CLASSES

Diameter class (inches)	Weight per cubic foot		Moisture content[1]
	Green	Oven-dry	
	Lbs.	Lbs.	Percent
0–1	23.2	14.1	65
1–4	22.6	14.2	59
4–6	26.9	15.6	72
Average	24.2	14.6	65
ASPEN			
0–1	23.9	13.0	84
1–4	19.8	9.7	104
4–6	19.5	9.4	107
Average	21.1	10.7	98
JACK PINE			
0–1	18.2	8.4	117
1–6	29.8	10.7	179
Average	24.0	9.5	148

[1] Based on oven-dry weight.

Factors affecting weight, in addition to specific gravity of species, include moisture content, percentage of bark and foliage, and size of chip. Studies by the Northeastern Forest Experiment Station (4) showed that knife setting, which affects texture of the chips, also affects weight of a given volume of green chips.

Although moisture content of wood cut during different seasons varies only slightly (8), recent investigations in northern Minnesota showed that m.c. of aspen was considerably higher in the fall and winter than other seasons (5). Therefore, the season may have some effect on weight of chips produced from aspen.

The m.c. of chips varied considerably (Tables 5, 6), due primarily

Table 6.—WEIGHT AND MOISTURE CONTENT OF WOOD CHIPS PRODUCED DURING GROWING SEASON WITH 12-KNIFE MACHINE, BY SPECIES AND DIAMETER CLASSES

Diameter class (inches)	Weight per cubic foot		Moisture content[1]
	Green	Oven-dry	
	Lbs.	Lbs.	Percent
OAK			
0-1[2]	(16.8)	13.5	(24)
0-1[3]	(16.6)	(9.6)	(73)
1-4	23.3	15.0	55
4-6	24.7	14.8	67
Average	24.0	14.4	61
ASPEN			
0-1[4]	16.1	10.9	48
1-4[4]	17.1	10.4	64
4-6	19.3	10.4	86
Average	17.5	10.6	66
RED PINE			
0-1	20.6	10.6	94
1-4	21.0	8.8	139
Average	20.8	9.7	116
APPLE			
0-1	22.2	12.5	78

[1] Based on oven-dry weight.
[2] Oak brush that was air-dried from February to June before chipping. Moisture content of this material therefore is not comparable with that of other samples and was not used to obtain average moisture content.
[3] Oak brush, freshly cut. This was the only test with hardwood material containing green foliage. Bracketed figures were not used in the averages for oaks. Because of the presence of foliage, green and oven-dry weights were far less than normal and were not used to obtain averages of these weights for oak.
[4] Cut during December; air-dried until June before chipping.

Table 7.—SUMMARY OF FIXED AND OPERATIONAL COSTS

Cost item	Basis of calculations	Cost per hour
		Dollars
Depreciation	$2,700 over 5 years (5,000 hours)	0.54
	OPERATIONAL COSTS	
Labor	2 men at $1.50 per hour[1]	3.00
Machine		
Gasoline	2.7 gallons at $0.25 per gallon	.675
Oil	5 qts. at $0.30, plus filter every 100 hours	.030
Lubrication	$0.50 every 50 hours	.010
Sharpen knives	$7.50 every 40 hours	[2] .188
Knife replacement	$100.00 every 2,000 hours	[2] .050
Belt replacement	$25.00 every 2,000 hours	[2] .012
Miscellaneous repairs	$50.00 every 2,000 hours	[2] .025
Sub-total	Machine operational costs	.99
Total	Fixed plus operational costs	4.53

[1] Substitute local wage rate.
[2] These cost estimates were furnished by the manufacturer of the chipper tested. Maintenance and replacement of knives in a 12-knife machine will cost about $0.03 more per hour than for an 8-knife model. Since most of the expense items in connection with knife maintenance are liberal, no cost was listed for the time required to change the knives.

to degree of seasoning of wood before it was chipped, with the exception of oak brush chipped with the 12-knife chipper.

The m.c. of brush and slash may vary considerably, depending on the season and length of time since cutting. Wood from the lower part of the tree usually contains more moisture than that from the upper portion (8). Material cut during the dormant season usually dries more slowly than similar material cut during the growing season. Faster drying rate of the latter results from more favorable temperature and humidity conditions. Transpirational loss due to green foliage also speeds up drying.

Oven Dry Weights: The oven-dry weights of chip samples averaged 15 pounds per cubic foot for oak, 11 for aspen, and 10 for pine (Tables 5, 6). Differences in weights of chips from material of various diameter classes of the same species resulted chiefly from the relative proportions of bark and foliage. For example, the U. S. Forest Products Laboratory reports the specific gravity of aspen bark is higher than that of aspen wood, while the bark of some species weighs less than the wood. Because weight of the chips is based on an average of only three 1-cubic-foot samples taken from each load of chips, possible variations within the load also may be expected to cause minor differences in the weights presented (Tables 5, 6).

From these tests it appears that the weight of green chips was not only variable but important. The weight of a volume of chips from fresh cut wood material was twice its oven-dry weight. It took only 100 cubic feet of chips from green wood to make a ton. The boxes of most trucks can be modified to hold a volume of chips whose weight will greatly exceed the rated capacity of the truck.

From the standpoint of reducing hauling costs and retarding deterioration of chips in storage, the material should be air-dried to some extent before chipping. However, resistance to chipping increases as it dries; therefore the extent of drying needs to be balanced with the cutting power of the chipper.

The modified machine chipped air-dry brush as fast as green material, but dry sticks over 3 to 4 inches in diameter were more difficult to chip than green wood of comparable size.

Settling of Chips

At the end of each test the volume of chips collected was measured. The truckload was then driven 1 to 4 miles and the volume remeasured. The volume of chips after settling was used for production rates and weight. It was found that chips settled between 2 and 4 per cent in cubic volume.

Costs

Costs of owning and operating this chipper are both fixed and operational. Fixed costs include cost of chipper, interest, and insurance. If the machine is operated continuously, depreciation would be spread over 5 years (Table 7). Where use is periodic, as in a farm operation, 10 years should be allowed.

Operational costs include gas, oil, knive sharpening, replacements, and labor. The latter is the most variable; therefore local rates may be substituted for the $1.50 rate calculated (Table 7). Another operational cost is the expense of towing the chipper.

Fixed Costs: Cost of the chipper in January, 1954, was $2700. Annual depreciation on a 10-year basis is $270; on a 5-year basis, $540. Assuming 1,000 working hours per year this amounts to $0.27 and $0.54 per hour respectively. No estimate is made of the salvage value, thus fixed costs are generous.

Operational Costs: Machine rates ranged from $0.99 to $1.02 per hour, depending on number of knives. Gasoline ranged from 2.2 to 3.3 gallons per hour. The knives require sharpening every 40–50 hours, depending on material. It is estimated knives can be sharpened 50 times before replacement, or a service life of 2,000 to 2,500 hours.

General Performance

The chipper was well balanced and mobile, riding easily behind a pickup truck at highway speeds up to 55 mph. Brakes are optional. No difficulty was experienced in moving the chipper during several hundreds of miles of driving over many types of roads. In the woods, similar portability was experienced.

No specific study was made of piling and crew organization. However,

the most efficient crew size for chipping from prepiled brush appeared to be two men, one feeding and one gathering. If brush were unpiled, a 3-man or larger crew would be more efficient.

When wood over 4 inches in diameter was chipped continually, the chipper was underpowered. The sticks gradually slowed down the cylinder after 2 or 3 feet of length had been chipped. If sticks exceeded 5 or 6 feet in length, the operator was forced to hold back several times to allow the cylinder to re-accelerate and thus avoid engine stalling.

Both chippers appear to be well designed for safe operation, with moving parts covered. A remote possibility exists for the operator's clothing or glove to be pulled into the chipper. Knives are well-fastened in the revolving cylinder, with little possibility of being thrown. Safety goggles are recommended for protection against dust and whipping branches.

Uses for Portable Wood Chippers

Utilization of Logging Residue and Timber Stand Improvement.

Pulp Chips. Pulp manufacturers prefer fairly uniform chips of about 5/8-inch length, generally free of bark, leaves, etc. Some require segregation of species. Such requirements rule out chips of the type produced by this chipper.

Some mills use rough jack pine, aspen, and rough hardwoods, and may constitute a market for larger sticks of sufficient volume and acceptable price. The U. S. Forest Products Laboratory has produced satisfactory paper from one experimental run of aspen chips produced from 1 to 4 inch wood with the portable chipper tested.

If usable chips can be produced at a price substantially lower than pulpwood, markets should be available at the mills. This type of portable chipper would be restricted to salvaging sticks up to 4 inches in diameter on pulpwood logging operations. The trees could be skidded full length to concentration points and bucked. Sticks below 4-inch diameter could be chipped on the site (Fig. 4). Under current cutting practices, 30 to 50 per cent of the length of the stem is not utilized. A considerable volume remains unused, especially in larger trees (Table 8).

Chips for Agriculture. The U. S. Soil Conservation Service reports that chips have been used successfully in improvement of impoverished soils and maintenance of humus content (7). Other investigators (1) (6) have found chips are satisfactory mulching material for orchard trees, etc. Chips have been found to remain loose, clean, and dry when used as poultry litter (7). More recent tests (2) indicate good use of chips for cattle bedding.

Fuel. Chips are being used as fuel to some extent in the East. As yet such use has not developed in the Lake States.

Slash Disposal. Experience indicates that chipping is more expensive than burning and is justified only where the latter is impracticable, as in fire hazard areas (3) or for aesthetic value (Fig. 5).

Disposal of Roadside and Right-of-Way Brush. Brush usually cannot be burned along right-of-ways. Chipping is usually less expensive than hauling and burning, because in most instances it can be scattered as is.

Summary

The portable chipper tested was found to be well balanced and highly mobile. Two men comprise the most efficient size crew. Chip production rates varied with the 8-knife machine, from 77 cubic feet of chips per hour from oak limbs to 241 cubic feet from aspen wood. Chip rates increased with the diameter of material chipped, except for small jack pine limbs.

Rates with the faster cutting 12-knife chipper varied from 128 cubic feet for oak to 286 cubic feet for small oak brush. With this machine, rates decreased as diameter of the material increased, except for aspen.

Both machines had ample power for chipping up to 4-inch diameter wood. When wood 4 to 6 inches was chipped continually, the 12-knife chipper was underpowered.

Costs averaged about $1.53 per hour for operation and maintenance. The weight of a given volume of green chips was variable, depending on species and moisture content.

Oven-dry weight of chips varied with species. The volume of green chips in a truck decreased between 2 and 4 per cent due to compaction.

Chips from material 1 to 6 inches in diameter were small in size, ranging from 1/2-inch width, 1/4-inch length and 1/16-inch thickness to fine material equal to sawdust. Chips from small brush less than 1 inch were coarse and irregular in texture and size.

Ratio of wood chip volume to solid volume varied from 2.2:1 for oak and jackpine to 2.5:1 for aspen. Thus, a standard cord of wood will produce about 200 cubic feet of chips. Ratio of piled brush volume to wood chip volume varied from 13:1 to 20:1 for oak and aspen.

Chips produced from rough wood by portable chippers of the type tested are not generally used by the pulp industry mainly because of small size and lack of uniformity of chips, high proportion of bark and leaves, mixed species, and uncertain supply. If these objectionable features can be minimized, it should be possible to market chips from sticks 1 to 4 inches in diameter that are currently left in the woods on most pulpwood operations.

Table 8.—ROUGH VOLUME[1] IN CUBIC FEET OF THAT PORTION OF THE MAIN STEM OF ASPEN[2] REMAINING AFTER CUTTING TO VARIOUS UTILIZATION STANDARDS

D.b.h. (Inches)	Total height of tree – feet					
	40		60		80	
	Percent of stem length utilized in logging					
	50	70	50	70	50	70
	Volume remaining – cubic feet					
6	.9	.3	1.3	.4	—	—
8	1.6	.5	2.3	.7	3.1	.9
10	2.4	.7	3.6	1.1	4.8	1.5
12	3.5	1.1	5.2	1.6	7.0	2.1
14	4.8	1.4	7.1	2.2	9.5	2.9
16	6.2	1.9	9.3	2.8	12.4	3.8
18	7.8	2.4	11.8	3.6	15.7	4.8

[1] Bark comprises 13 per cent of the rough volume of aspen. Technical Note No. 362, Lake States Forest Experiment Station.
[2] Values for jack pine are about 5 per cent higher than values shown.
[3] Based on Tables 3 and 9 in "Composite Volume Tables and Their Application in the Lake States," unpublished manuscript, Lake States Forest Experiment Station.

Literature Cited

1. Allison, F. E., and Anderson, M. S. 1951. The use of sawdust for mulches and soil improvement. U.S.D.A. Cir. No. 891.
2. Brundage, Roy C. 1953. Wood chips—a good material for livestock bedding. Purdue Univ. Agr. Exp. Sta. Cir. 395.
3. Fahnestock, George R. 1953. Chipping takes the hazard out of logging slash. Northern Rocky Mountain Forest and Range Expt. Sta., Research Note No. 125.
4. Fenton, R. H., and McKusick, H. A. 1950. A pilot study of a portable wood chipper. Northeastern Forest Exp. Sta. Paper No. 37.
5. Jensen, Raymond A., and Davis, John R. 1953. Seasonal moisture variations in aspen. Minnesota Forestry Notes, No. 19.
6. McIntyre, A. C. 1950. Increased use for wood on the farm. Jour. Forestry, 48:9.
7. ————. 1952. Wood chips for the land. U.S.D.A., Soil Cons. Serv. Leaflet No. 323.
8. Peck, E. C. 1953. The sap or moisture in woods. U.S.D.A., Forest Products Laboratory, Report No. 768.

New Uses For Wood[1]

RALPH H. MANN

Engineer, Service Bureau, American Wood Preservers' Association, New York, N. Y.

Preservative-treated wood is regaining markets lost to substitute materials. In addition, use of preservatives is developing new markets for wood products, thus benefiting the entire lumber industry.

PRESSURE-TREATED TIMBER is reclaiming earlier wood markets that for one reason or another had been usurped by substitute materials. Most of these substitutes are inferior to wood that has been made durable by thoroughly tested chemical treatments.

Users in most instances resort to these alternate materials for places where untreated wood might decay or be destroyed by insects, either because quantities required are small and in many instances cannot be procured locally, or because those responsible for the construction work are unacquainted with the real merits of pressure treated wood.

Durable Products

The treating industry, through the selection of satisfactory chemicals and tested methods of injecting them, can transform wood into a durable product that in many cases will outlast so-called permanent materials even when subjected to most severe conditions of exposure. Wood pressure treated with suitable preservatives in accordance with the recognized standards resists attack by decay, insects, or marine borers. Other standard chemical formulations make wood fire resistant. These preservatives which prevent fire spread also contain ample proportions of standard preservative salts to inhibit decay or insect damage.

Increasing demands for treated timber products are coming from farmers and small building contractors because these people are being informed of the economic advantages of pressure treated lumber through better programs of public relations and advertising. These fields, relatively unexploited until quite recently, offer promising spheres of development for those seeking expanded markets for properly treated forest products. Moreover, development in these fields results in greater use of lumber generally.

There are certain vital parts of wooden structures that are particularly subject to decay and insect attack. Protecting these parts by using pressure treated lumber insures permanence of the whole building and relieves the owner from constantly recurring items of maintenance expense. Good design will protect most of the lumber in a building indefinitely. However, timber that can not be destroyed by decay or insects must be used for these vulnerable members if permanence is to be achieved.

Modern architecture seems to prefer houses close to the ground. In such cases wood in lower floors absorbs sufficient moisture to decay in a short time unless it is properly treated with an effective preservative. This is equally true of houses founded on concrete slabs in contact with the earth. Either type, however, is immune to the attack of wood-destroying agencies if properly preserved wood is used in contact with the ground or slab.

Many Uses

The American wood preserving industry is active in forest conservation and has made two distinct contributions to conservation of the country's timber stands. Pressure treated timber in exposed structures lasts four or five times longer than its untreated counterpart. Thus, by the elimination of periodical structural replacements the drain on our producing stands is materially lessened. Preservative treatment also has made it possible to use fast-growing species economically for many purposes. These species possess excellent mechanical properties, but in their natural untreated state lack the durability to permit their use in any but the most temporary installations. They are, however, particularly adapted to preservative treatment because their large sapwood content assures deep penetration and uniform distribution of the preservatives when they are treated by modern pressure processes.

The great change that has taken place during the last few decades in treated timber requirements is illustrated by the case of railroad ties. There are approximately 1 billion crossties in American railway tracks, or an average of about 3,000 ties per mile of track. No satisfactory substitute has ever been found for the wood railway tie, although more than 2,000 patents have been issued for substitutes.

Fifty years ago more than 300 ties per mile of track were required for renewal purposes every year by United States and Canadian railways. Many roads which did not have naturally durable species accessible installed 400 and more ties per mile as replacements each year.

Through the art of wood preservation, however, service life of ties has been increased from 5, 6, or 7 years to 33 years. In 1953 the average number of ties required for replacements in each mile of track was less than 90. Thus, annual requirements have been reduced by approximately 70 million ties during the period since preservative treatment became common.

Almost 80 per cent of the wood treated in the United States 35 years ago consisted of railway cross and switch ties. Today railway ties represent only 43 per cent of the gross quantity of wood passing through the treating plants of this country. This is a tremendous drop in annual requirements and if we are to use effectively the harvest of our forests, other outlets for this quantity must be found.

Pole-Type Building Advantages

The most promising prospects for increased consumption of timber today appear to be in the various building fields. Pole-type farm buildings and fence posts utilize tremendous quantities of wood each year. The pole frame building has become familiar in nearly every section of the country.

Such structures, by reason of their low cost and durability, are receiving both notice and acclaim in farm journals and from those connected with our agricultural schools throughout the na-

[1] Presented at a meeting of the Northeast Section, FPRS, Nov. 4-5, 1954, in New York City.

The author: Ralph H. Mann received a B. E. in C. E. from Tulane University in 1920. He spent nine years in engineering work before joining the AWPA Service Bureau in 1929. Mann is a recognized authority on foundation piles, marine waterfront structures, and other heavy construction.

tion. Representatives of the Department of Agriculture's Forest Utilization Service also have supplied excellent information that is aiding farmers to procure economical structures for a fraction of the cost for equivalent shelter for stock or farm products in the conventional type of buildings.

Pressure treated fence posts have become an extremely important commodity—22 million of them were sold in the United States last year. Their value is appreciated more as labor costs advance and time diverted from actual agricultural pursuits to maintaining fences or to other farm repairs becomes increasingly expensive.

Providing treated timber for home repairs and for small structures is also one of the most promising means of building up demands. Each user buys a comparatively small lot, but their requirements in the aggregate total up to a vast quantity of lumber.

The greatest obstacle to this use in the past has been the lack of supplies at local lumber yards. Where carload lots are involved, procurement has presented no difficulties. The small user, however, could not afford to bring these small lots from some distant plant. The cost involved in procurement, therefore, frequently discouraged the use of treated lumber for replacing decayed or termite-ridden members in buildings or the use of treated timber for other minor structures where only a small quantity of lumber was required.

Wood preservers recently have made a concerted effort to improve retail distribution, with the result that the number of retail outlets has increased rapidly within the last few years. Success so far seems to indicate that the time is not far distant when properly treated lumber for the home owner and other small builders will be available at local yards in practically all communities of the country.

Research for Better Products

Both the U. S. Forest Products Laboratory and the pressure treating industry are continuously engaged in research to discover better techniques for treating timber for various uses. Tests to determine the effectiveness of all promising preservative chemicals are conducted regularly in the field and at the laboratories.

The Service Bureau of the American Wood Preservers' Association recently allocated several thousand dollars for the U. S. Forest Products Laboratory to use in determining the relative effectiveness of pressure and non-pressure processes to protect wood from deteriorating agencies. Within a year sufficient information should be developed to permit an accurate appraisal or comparison of the various methods in common use. A complete report will require considerable time, however.

Research by individual plants has resulted in the development of artificial seasoning processes for conditioning forest products for treatment in a few hours. These processes not only preclude the necessity for holding material for long periods in treating yards, but they also cut down any losses caused by deterioration during the storage period.

The long recognized standard wood preservatives of the American Wood Preservers' Association are coal-tar creosote and creosote-coal tar and creosote-petroleum solutions. Other excellent standard oil-borne preservatives are pentachlorophenol and copper napthenate, dissolved in petroleum oil.

The recognized standard water-borne preservatives are chromated zinc chloride and tanalith (Wolman salt). Because of disuse, zinc chloride and zinc meta arsenite were dropped as AWPA standard water-borne salts in 1954.

There are, however, several additional and promising water-borne wood preservatives which recently were recognized as standards by the American Wood Preservers' Association.

These are:

(1) acid cupric chromate (celcure)
(2) ammoniacal copper arsenite (chemonite)
(3) chromated copper arsenate (greensalt or erdalith)
(4) chromated zinc arsenate (boliden salt)
(5) copperized chromated zinc chloride.

These preservatives were approved by AWPA only after tests in actual service over long periods of time had established conclusively their efficacy in protecting wood under the conditions of exposure for which they are recommended. To be effective, however, they must be injected by pressure processes that drive them deeply into the wood and insure the retention recommended for each.

The best preservative known will not increase the life of wood appreciably unless it is properly applied. The selection of a treating process is therefore as important as the choice of a preservative.

The superiority of pressure treated lumber as compared with non-pressure treated lumber has been established definitely by repeated experiences over a long period of years. If the maximum service against decay, insect, or marine borer attack is to be realized, the preservative must be injected by pressure processes. In this way the preservative is uniformly distributed through the treated zone in sufficient quantity and for sufficient depth to repel insects, fungi, or other organisms that destroy untreated wood. These processes permit all steps of the treating cycle to be rigidly controlled and generally insure the greatest economy in the use of the treated materials.

New Markets

If the wood preserving segment of America's lumber industry is able to transform wood into a *Better Product*, then it follows that *New Markets* for the wood preserving industry also mean new markets for the lumber industry.

As to the importance of wood preservation to the lumber industry, during the last ten years wood preservers have treated a gross volume of wood *equivalent* to about 10 per cent of the annual lumber production in the United States. When all round material, hewn ties, etc., are deducted from the equivalent 10 per cent, however, only about 2 per cent of saw lumber is preservatively treated. This proportion could be increased three- or fourfold economically if all wood used in exposed places were preservatively treated.

As a result of efforts by the pressure treating industry, well selected stocks of treated lumber, posts, and piles are carried by retail yards in many communities and the number of localities where such stocks are maintained is constantly increasing.

The Service Bureau maintained by the industry has been expanded recently so that correct and timely information can be channeled to all segments of the population, both rural and urban. Home owners and others concerned with smaller local building programs are becoming better acquainted with treated timber and its uses.

The observation that if a man builds a better mousetrap the world will beat a path to his door is undoubtedly a sound business maxim. Before the paths can become numerous or densely traveled, however, the public must be made aware of the article's superiority and how it can be obtained.

Decay in Exterior Millwork[1]

RALPH M. LINDGREN

Forest Products Laboratory,[2] Forest Service, U. S. Department of Agriculture

Discusses factors related to decay in millwork and how decay can be controlled by using dry, naturally resistant, or preservative-treated wood. Seasoning methods and preservative treatments are described.

RELATIVELY FEW BUILDINGS are seriously damaged by decay in sash, frames, doors, and other exterior millwork. The problem cannot be ignored, however, because when such decay occurs, it often requires expensive repairs, and it is usually so conspicuous that even infrequent cases lead to distorted impressions of the importance of the problem. The result is that wood may be discriminated against unfairly in competition with other materials. Actually, decay damage in exterior millwork is seldom an example of failure of wood as a material. Most cases can be traced instead to improper practices in the manufacture or use of wood.

Factors Affecting Decay in Exterior Millwork

Moisture Content: The moisture content of wood usually is the important factor that determines whether decay will occur. It is also the factor that can be most readily controlled in the great majority of uses for wood products. For infection by decay fungi, the moisture content must be more than 20 per cent of the oven-dry weight of the wood. This means that more water must be present than dry wood will absorb in an almost saturated atmosphere. Therefore, kiln-dried or fully air-seasoned wood will not decay unless it is rewetted by free water.

These water requirements for decay fungi make it obvious why drying wood rapidly and keeping it dry is commonly stated as the first principle of decay control. The second principle is to use naturally resistant or preservative-treated wood, if moisture conditions cannot be controlled.

Kind of Wood Used: The sapwood of all species of native woods has little resistance to decay. Furthermore, only the sapwood is susceptible to molds and blue and black stain fungi that not only discolor but also increase the water-absorptiveness of wood.

There are two reasons for the low resistance of sapwood to decay: (1) sapwood lacks the natural preservative chemicals that are found in heartwood of the durable species; (2) it absorbs water much more quickly than heartwood, when exposed to rain or other sources of moisture. However, sapwood generally also takes preservatives more readily than heartwood, and when thoroughly treated with an acceptable preservative it is as resistant to decay as heartwood of most durable species.

Heartwood of different species varies greatly in decay resistance. In general, such woods as cypress, red cedar, and redwood have highly durable heartwood, but most of the pines, spruces, true firs, and hemlock have heartwood that is only moderate or low in resistance.

Questions have arisen recently as to how the woods used commonly for exterior millwork compare in natural decay resistance. Manufacturers wonder, for instance, whether they can safely substitute western white pine or ponderosa pine for some other species that has become difficult to obtain. Unfortunately, there are no adequate service or field records on many of the millwork species, probably because such woods are seldom used, either treated or untreated, under conditions highly favorable to decay.

Resistance Compared

To answer some of these queries, J. W. Clark of the Forest Products Laboratory recently conducted laboratory tests on the relative decay resistance of heartwood of a number of woods. His tests indicated that of the pines, the heartwoods of longleaf, eastern white, and sugar pine were somewhat more resistant than those of ponderosa, western white, red, jack, loblolly, and lodgepole pine. None of the pines, however, proved decay resistant enough to insure long-time service of wood exposed to conditions conducive to decay.

Included also in Clark's tests were such woods as western hemlock, noble, and lowland white fir, and Engelmann spruce. All of these ranked among the lowest of the woods tested in resistance of heartwood to decay.

In practice, there are no restrictions on sapwood in lumber used for sash, frames and similar exterior millwork. As long as this practice continues, there is little reason to differentiate between the relative decay resistance of heartwood of the species that are being used commonly for this purpose.

Condition of Wood

Wood that already has become infected by stain, mold, or decay fungi during seasoning and storage presents a particularly high decay hazard if exposed to moisture during later use. One reason for this is that decay fungi can remain dormant for weeks or months and then resume growth each time the wood is moistened. Another reason is that infected wood exposed to rains, or other sources of moisture, absorbs water much more readily than uninfected wood.

Recent studies have shown that this is as true of wood with invisible molding as it is of wood with stain or early decay infections. Until this disclosure, molds were believed to have no effect on wood other than superficial discoloration of sapwood. However, a colorless stage of some of the common molds is now known to penetrate deeply into wood, leaving no visual evidence of their presence. Such infected wood may absorb 4 or 5 times more water than unmolded wood. Similar increases in permeability, but of smaller magnitude, were already known to accompany the visible discoloration of wood by sapstaining fungi.

What is the significance of the greater absorptiveness of molded or stained wood in relation to decay of wood in use? For wood exposed to the elements, it means that the amount of water needed for decay is most likely to be present in wood having any type of prior infection.

Furthermore, swelling and shrinking occur more frequently in the absorptive

[1] Presented at Fall Meeting of Ohio Valley Section of Forest Products Research Society, Oct. 14, 1954, Louisville, Kentucky.

[2] Maintained at Madison, Wis., in cooperation with the University of Wisconsin.

The Author: Ralph M. Lindgren, Chief, Division of Forest Disease Research, U. S. Forest Products Laboratory, has been engaged since 1926 in work on the causes and control of fungus defects in wood. He received B.S. in forestry, M.S. and Ph.D. in plant pathology and botany from U. of Minnesota.

infected wood. Such dimensional instability encourages the opening of joints and loosening of fastenings in finished products, thereby providing avenues for the entrance and collection of water. It is now known that this factor of prior infections in lumber explains certain cases of early and rapid decay of millwork that proved so perplexing in the past.

Adverse effects from changes in permeability due to infections also influence the preservative treatment of wood. Thus, when the method of dipping millwork in toxic oil solutions became common, occasional pieces of ponderosa pine were found to absorb excessive amounts of preservative. Such so-called sinker stock not only increased the cost of treating but also led to troublesome discoloration and failure of paint on millwork in use. Recent studies in several laboratories have disclosed that mold and other infections explain at least some of this abnormal absorptiveness.

Exposure Conditions

Climatic conditions have an important bearing on the life of wood exposed to the elements. In general, decay is more rapid in warm, moist regions than in the colder or drier parts of the country. For wood exposed above ground, the principal source of water is rain.

A factor of some importance in the colder parts of the country is the trend toward air humidification and tighter window construction. Both tend to favor higher humidities than have been customary in buildings in the winter, thereby encouraging condensation of moisture on windows.

Considering local conditions of exposure, the moisture leading to decay in exterior millwork is mainly from rain seeping into joints. The hazard is highest at joints because wood absorbs water most readily through the end grain. According to the extensive studies of A. F. Verrall of the Southern Forest Experiment Station, water seepage and collection in joints usually is associated with such practices as narrow roof overhang, clogged gutters or downspouts that discharge rainwater directly against the exterior woodwork, and the use of vapor barrier papers as sheathing papers. If highly absorptive infected wood is also present, the build-up of moisture in joint areas may easily lead to serious decay troubles.

Prevention of Decay in Exterior Millwork

Keeping Wood Dry: Control of moisture is our first line of defense in protecting most wood products against decay. Such control can also be very helpful in the case of exterior millwork.

As a start in this direction, wood that already is infected, and therefore absorptive, should be avoided. This means that every practical effort must be made to control infections at sawmills, and obviously infected wood should be sorted out in the manufacture of exterior millwork. Actually, infections cannot be eliminated completely under present conditions because of certain logging practices and the fact that mold presence in wood often cannot be detected. Nevertheless, there is little excuse for some of the infected millwork that has been placed in buildings, particularly since practical control methods are available for lumber during seasoning. Among these methods are kiln drying the wood green from the saw, which insures the greatest amount of protection against infected or too-wet lumber.

Other methods that are effective if properly done are air seasoning, or dipping the lumber in cheap and effective chemical solutions to supplement air seasoning when necessary. Preventing infections in lumber after shipment from mills demands only that dry lumber be kept under cover until it is used. The importance of installing sound, dry lumber in exterior millwork cannot be overemphasized.

A second step toward preventing sufficient take-up of water for decay is to use construction designs that both reduce rain seepage and collection and promote rapid drying when seepage does occur. Among these preventive measures are adequate roof overhang, efficient eaves, gutters, and downspouts, flashing of window and door trim or any other projections from the wall, and the use of permeable, "breathing" paper when sheathing paper is required. In northern climates where condensation on windows is likely to provide the moisture for decay and stain troubles, the use of storm windows and greater care in ventilating humid rooms are of considerable help.

Contrary to common belief, paint alone cannot be relied upon to keep wood dry. One of the main reasons for this is that moisture usually enters at joints where the paint has cracked due to the swelling and shrinking of wood or the working of joints. When this happens, the paint may favor decay because of its retarding effect on drying of the wood.

Preservative-treated Wood: Some of the preferred building designs make it impossible to keep the moisture content of exterior millwork too low for decay. In such cases, naturally resistant wood or preservative-treated wood can provide adequate protection. The heartwood of such resistant woods as cypress and cedar, for instance, will insure good service life. However, these woods are not always readily obtained, and other woods may be preferred for certain types of millwork.

For window sash and frames, main reliance is now being placed on preservative-treated wood. The use of preservative solutions has increased greatly in recent years, and there are many who feel that the treatment of all sash, for instance, has much to recommend it in the present competition between wood and metal.

Of the different methods of preservative treatment in use, impregnating the wood under pressure with acceptable oil- or water-carried preservatives insures the most uniform and lasting protection against decay. Recently, a method employing an initial vacuum before treatment, followed by a second vacuum for surface drying the treated wood has come into increasing use.

Probably the most common method of treating millwork involves a brief dip, usually for about 3 minutes, in oil-preservative solutions. With this method, we have the unprecedented example of a millwork manufacturer's association that has set up and is policing minimum standards of treatment. These standards cover both the preservative materials and their application by the dipping method. Undoubtedly treatments of this type give worthwhile protection provided all cutting and shaping precede treatment, and, as is true with millwork, the surfaces exposed during use are painted.

The incorporation of water repellents to the preservative solution appears to give added protection and is being done to an increasing extent. It is necessary, of course, that both water repellent and oil carrier be of types that will not interfere with painting within a short time following treatment.

Increasing Lumber Core Yields with a Patched Strip Core[1]

JAMES S. BETHEL and W. B. WOODRUM
Wood Products Laboratory, North Carolina State College, Raleigh, N. C.

Patching strip cores permits use of low-grade lumber in manufacturing core stock. Tests indicate that patches will not print through panel faces under normal controlled operating conditions.

ONE OF THE MOST CRITICAL problems facing the wood-using industries of America today is that of manufacturing finished products of a quality equal to or better than that which they have produced in the past from a raw material which is steadily decreasing in quality and increasing in price. The old growth trees which provided large, clear cuttings of lumber and whole sheets of high quality veneer are virtually gone from American forests. The average log delivered to the sawmill and veneer plant is smaller in diameter and lower in grade than it was just a decade ago. It is incumbent upon the wood-using industries to develop techniques for using lower quality raw material to produce a high quality finished product.

This situation is nowhere more acute than it is in the production of lumber core plywood. Yellow poplar has long been the standard core stock material for thick, fancy-faced furniture and architectural panels. Where expensive faces are placed on the panels and where high gloss finishes are ultimately to be used, the industry has generally required that the finished core be of high quality and relatively free from defect. This has usually meant that lumber core was produced from No. 1 common and No. 2A common. Some producers use No. 2B common, but No. 3 common and cull grades are rarely, if ever, used.

As the log quality continues to deteriorate, the percentage of No. 2A and better produced at the sawmill decreases. Accordingly, it is becoming increasingly difficult for the lumber industry to meet the demand of the furniture and plywood industries for this quality of lumber. The price, of course, goes up. At the same time, the larger quantities of less desirable No. 3 common and cull lumber present the lumber manufacturer with a marketing problem.

It is of interest both to the lumber supplier and the plywood and furniture manufacturer to develop techniques which would make it feasible to utilize No. 3 common and cull poplar for lumber core and to increase the yield of core from all grades of poplar lumber. This is not a new area of research. One answer to the problem is the chipcore or particle board. It was the objective of this research to explore the possibilities of another solution.

Better Yield of Core

It was felt that a good method of improving yield might be to produce a strip core including the defects present in the lumber and then patch the unacceptable defects. It has already been well established, both in the United States and in Europe, that the strip core results in better yield of core than can be obtained by the conventional process.

The strip core is commonly made[2] by ripping the lumber to a width slightly greater than the thickness of the core to be produced. The defects are then cut out of the strips. The strips are turned 90° so that the original surfaces of the board become the glued faces. Because the strips are narrower than the usual lumber core member, there is somewhat more loss in saw kerf in the ripping operation. This is more than compensated for in savings in planing waste.

To further increase the yield of core from poplar lumber, the method of producing strip core was modified during this study. The lumber was crosscut to length without cutting out defects. Two lengths of core were produced and the only consideration given to a defect was to select a length of core that would avoid positioning a defect on the end of a piece.

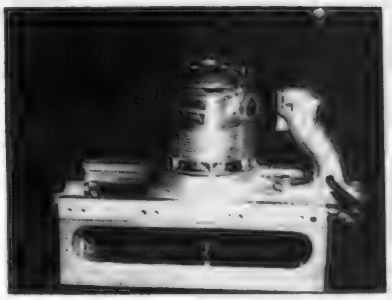


Fig. 1.—Router used to remove defect.

The lumber was ripped to width as in the conventional strip core operation, turned 90°, and glued. In laying up the core, defect-free pieces were placed in the band positions on the edges of the core and strips were placed so that defects in adjacent strips were not next to each other.

After gluing, all unacceptable defects were patched using the American Manufacturing Company equipment developed for plywood patching. The patches used were made from $\frac{3}{16}$-inch yellow poplar veneer, were oblong in shape with circular ends and beveled ends and edges. They were $1\frac{1}{32}$ of an inch wide and $3\frac{3}{16}$ inches in length.

The area to be patched was routed out with a router of the type shown in Figure 1. The depth of the routed area was slightly less than the thickness of the patch to allow for the desired pressure on the glue line when the patches were set. The patches were quickly set with a hot plate press or with the use of a high frequency generator and a cold press.

To determine what yield might be expected using this procedure, 250 feet from each of four grades of lumber was converted into $\frac{5}{8}$-inch strip core. The four grades utilized were: No. 1 common, No. 2A common, No. 2B commont, and a mixture of No. 3 common and cull. The cull boards made up the bulk of the lower grade and were culled principally for severe end splits or because they were mis-cuts.

Upgrading Core

The defects present in each core were examined to determine how many would have to be patched to raise the grade

[1] A contributed article.

The Authors: James S. Bethel is Director, Wood Products Laboratory, and Professor of Wood Technology, School of Forestry, N. C. State College, Raleigh. He attended U. of Washington and Duke U., holds B.S., M.S., and Ph.D. degrees.
W. B. Woodrum, Jr., holds B.S. from Virginia Polytechnic Institute, Master's in Wood Technology from N. C. State College. He was research assistant at N. C. State in 1953–54, is currently serving in U. S. Army.

[2] Colucci, G. Special Machines for Utilization of Waste Slabs for Clued Core Stock. Proceedings, Forest Products Research Society. 1948.

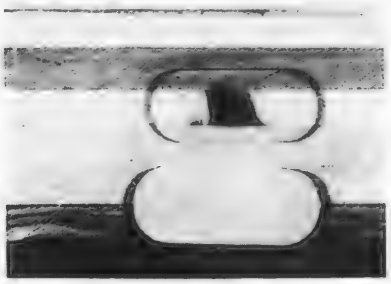


Fig. 2.—Defect routed out of strip core. Patch below the routed area will be used to cover defect.

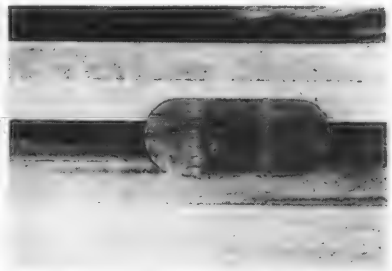


Fig. 3.—Patch is glued into core with hot press or high frequency press.

Fig. 4.—Electric resistance heated hot plate press for patch setting.

Fig. 5.—Press equipped for high frequency curing in patch setting operation.

Fig. 6.—Patched strip core after surfacing.

of the core to A grade and how many to raise the grade to B grade. The following grade specifications were used:

A Grade Core—No holes, only tight pin knots and snurls allowed, no split over $\frac{1}{16}$ inch in width allowed, must clean up face side.

B Grade Core—No holes, only tight pin knots and snurls allowed, no split over $\frac{1}{16}$ inch in width allowed, sound knots allowed as long as no checking is present, must clean up face side.

Table 1.—YIELD OF STRIP CORE AND NUMBER OF PATCHES REQUIRED FOR EACH OF FOUR LUMBER GRADES

Grade of Lumber	Percent Yield Sq. Ft./ Bd. Ft.	Number of Patches per Square Foot of Core	
		To make B Grade Core	To make A Grade Core
#1 Common	78.09	.05	.08
#2 A Common	76.98	.05	.34
#2 B Common	78.59	1.31	1.72
#3 Common and cull	68.09	.52	.77

Table 1 shows the yields obtained in the production of strip core from the various grades of lumber and the number of patches required to produce A and B grade cores. The variation in yield among the top three grades of lumber simply reflects the average length and width of the boards. Since no defects were cut out, the major source of waste was one strip on the edge and one piece trimmed from the end. The reduced yield in the cull grade resulted mostly from end splits and shake.

In the first three grades, the number of patches accurately reflected the number of defects in the grade. The relatively low number of patches required in the cull grade was due to the fact that many of these boards were free of defects other than mis-cutting, splits, and shake. These defects reduced yield but resulted in panels which did not require too much patching.

Test for Print-Through

One of the objections frequently raised against patching lumber core is that the patches will show or print through the face, particularly when a high gloss furniture finish is put on the panels. To test the validity of this objection, an experiment was conducted. It was felt that it was necessary not only to evaluate patches installed properly, but also to study defective patching operations as well.

The deficiencies in patching technique most likely to result in print-through appeared to be a poor fit of the patch into the routed area and a material discrepancy in moisture content between the patch and the core.

For the first experiment, 80 cores were prepared. 20 had good fitting patches (control). 20 were prepared so that the length of the routed area was $\frac{1}{16}$-inch longer than the length of the patch, resulting in a $\frac{1}{16}$-inch gap at the end of the patch. In the same way, 20 cores were prepared with $\frac{1}{8}$-inch gaps and 20 with $\frac{3}{16}$-inch gaps.

These cores were then reconditioned at an equilibrium moisture content of 9 per cent. They were then planed to $\frac{5}{8}$-inch in thickness.

The holes produced by the deviations between patches and routed areas were filled with a conventional wood filler in 10 of the cores in each deviation group. The other 10 cores in each group were left unfilled. Five of the filled cores and 5 of the unfilled cores in each deviation group were laid into panels with blond (Prima Vera and Avodire) faces. The remaining cores in each deviation group were laid up into panels with dark (mahogany) faces. Yellow poplar $\frac{1}{16}$-inch veneer was used for crossbanding and 1/28-inch veneer was used for faces.

An additional 40 panels were made in order to determine the effect of differences in moisture content between the patch and the core. The 20 cores used as the control in evaluating mis-fit patching were also used as the control in this determination. Of the patches used in these cores, 20 were at an equilibrium moisture content of 1 per cent, 20 at 9 per cent (control), and 20 at 23 per cent. Ten of the cores in each of the moisture content groups were planed and laid up immediately following the patching operation. The remaining cores were reconditioned at an equilibrium moisture content of 9 per cent before planing.

Five of the cores that were planed immediately and 5 of the reconditioned cores in each moisture content group were laid up into panels with blond wood faces. The remaining cores in each of the groups were laid up into panels with dark wood faces.

All of the panels produced were drum sanded at Thomason Plywood Corp., Fayetteville, N. C., within twenty-four hours after they were laid up. This was done in order to eliminate the possibility of sanding out any irregularity on the face of the panel which might have been produced by dimensionel changes in the patches as they equalized to the surrounding equilibrium moisture content.

A high-gloss type finish was applied in order that any irregularities which might have been present in the faces of the panels would be more perceptible. The finishing operation was performed by Williams Furniture Co., Sumter, S. C., approximately one week after the sanding operation.

Table 2 summarizes the panels prepared for these tests.

The faces of the panels were inspected carefully for patch print-through five weeks after finishing and again

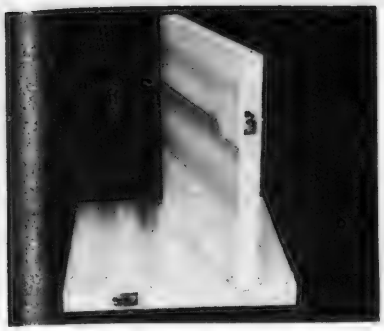


Fig. 7.—Cross section of patched defect.

seven months after finishing. The panels were stored in a laboratory room heated for the first two and one-half months and unheated for the next four and one-half months. None of the patches printed through at either inspection.

Influence of Cross-Band Thickness

A second experiment was conducted to determine the influence of cross-band thickness on print-through. Twelve panels were prepared and six patches were inserted in each panel. The cores were conditioned to 9 per cent moisture content. One patch was put in at 9 per cent moisture content, one at 1 per cent, and one at 23 per cent. In addition, one patch had a $\frac{1}{16}$-inch deviation, one an $\frac{1}{8}$-inch deviation and one a $\frac{3}{16}$-inch deviation.

Figure 8 illustrates the arrangement of the patches in the panels. Six of the panels were prepared with a 1/20-inch crossbanding and six with a $\frac{1}{32}$-inch crossbanding. In each group half the panels were planed immediately after patching and half were planed after conditioning at 9 per cent equilibrium moisture content.

Mahogany faces of 1/28-inch were put on the panels. They were sanded with an automatic stroke sander in the laboratory and finished with a high gloss cordovan finish in the laboratory. These panels were also inspected five weeks after finishing and seven months after finishing.

Table 2.—DESCRIPTION OF THE 120 CORES PRODUCED FOR THE EVALUATION OF THE PRACTICABILITY OF PATCHING STRIP CORE

10 cores—$\frac{1}{16}$-inch deviation between end of patch and end of routed area, deviation filled.	10 cores—$\frac{1}{16}$-inch deviation between end of patch and end of routed area, deviation not filled.
10 cores—$\frac{1}{8}$-inch deviation between end of patch and end of routed area; deviation filled.	10 cores—$\frac{1}{8}$-inch deviation between end of patch and end of routed area; deviation not filled.
10 cores—$\frac{3}{16}$-inch deviation between end of patch and end of routed area; deviation filled.	10 cores—$\frac{3}{16}$-inch deviation between end of patch and end of routed area; deviation not filled.
10 cores—Core at 9% E.M.C.; patch at 9% E.M.C.; planed immediately after patching.	10 cores—Core at 9% E.M.C.; patch at 9% E.M.C.; conditioned before planing.
10 cores—Core at 9% E.M.C.; patch at 1% E.M.C.; planed immediately after patching.	10 cores—Core at 9% E.M.C.; patch at 1% E.M.C.; conditioned before planing.
10 cores—Core at 9% E.M.C.; patch at 23% E.M.C.; planed immediately after patching.	10 cores—Core at 9% E.M.C.; patch at 23% E.M.C.; conditioned before planing.

Note: One-half of the cores in each of the above groups made into panels with blond faces; the remaining cores in each of the above groups made into panels with dark faces.

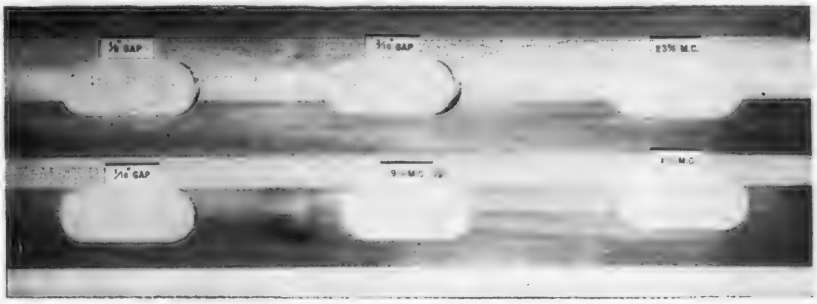


Fig. 8.—Layout of experimental patched strip cores designed to test print-through of patches.

None of the panels with 1/20-inch crossbanding showed patches printing through. Of the panels with $\frac{1}{32}$-inch crossbanding, four showed no printing through of any patches. One showed printing through only of the patch with the $\frac{3}{16}$-inch gap and one showed printing through of all three patches with gaps. None of the panels with $\frac{1}{32}$-inch crossbanding showed printing through of the well fitted patches regardless of moisture content.

Conclusions

These experiments indicate that a patched strip core will not print through the finished face of the panel except where the crossbanding is much thinner than that normally used and where the patch has been poorly fitted. Conditions as extreme as those which produce print-through in this experiment ought not to be encountered in a reasonably well controlled production operation.

The patched strip core permits low-grade lumber to be used in the manufacture of core stock. It should be possible to reduce the labor cost required to produce core stock if a gang rip saw is installed and if the rough end is conveyorized, since much of the judgment required of operators in crosscutting and ripping can be eliminated.

The operation does require the added expense of patching. No valid estimate of the cost of patching could be obtained since laboratory operations are not comparable to production operations. However, it should be noted that this same patching operation has proved to be practical with gum stock panels and this suggests that its cost is not likely to be so great as to make it uneconomical for lumber core.

Adhesives in Glued-Laminated Timber Construction[1]

NORMAN F. SMITH

Technical Representative, Monsanto Canada Ltd., Montreal, Que.

Discusses growth of glued-laminated timber construction industry on North American continent and outlook for the future. Describes advantages and limitations, preparation of lumber, types of adhesives, adhesive properties required, and methods of fabrication.

GLUED-LAMINATED ARCHES, literally "shop grown" of kiln dried lumber to exact shapes and dimensions specified by the designer, can serve as primary structural members for the walls and roofs of new buildings. Preserving all the natural beauty of the wood, laminated arches are adaptable and appropriate for both traditional and contemporary architecture.

Arches are only one example of end use in the glued-laminated timber construction industry, an industry which has expanded rapidly in North America since the end of World War II.

Growth of the Industry

Introduced in Europe prior to World War I, glued-laminated construction has been practised successfully there for the past 40 years. Originated by Otto Hetzer of Weimar, Germany, it is known in many parts of Europe as the Hetzer Construction or Hetzer System (7)[2].

The term "glulam" is often applied to wooden structures or structural components composed of laminations of wood whose grain directions are all substantially parallel and joined with a water resistant glue, regardless of the shape or use of the members.

Glued-laminated construction is used extensively in Germany, Sweden, and Switzerland, with lesser development in Denmark and Norway, and some reported use in Austria and Czechoslovakia.

European uses of glued-laminated beams and arches include erection forms for stone and concrete bridges, roof supports, airplane hangars, auditoriums, band stands, bath houses, chemical and other factories, churches, and foot and vehicle bridges.

In the United States, definite information on the first uses of glue in structural members is lacking but apparently no extensive development occurred prior to the installation of the glued-laminated arches in the service building at the Forest Products Laboratory in 1935.

At the beginning, the new firms in the United States who pioneered in the laminating of lumber into timber and structural members met with moderate encouragement. However, their background of experience was found inadequate, the technique had no effective sponsorship, strength and durability factors were relatively unknown quantities to architects, contractors, and civic building code authorities, and there were no recognized standards or established testing procedures. Much of the product was made to special order, and suitable workshops and equipment were exceedingly rare.

During World War II, due to an acute shortage of steel, the construction of government buildings for defense purposes provided the needed stimulus to promote large scale use of glued-laminated structural members. It was proven at that time that for most structural actions such as occur in trusses, beams, and columns, wood was stronger, pound for pound, than structural steel.

Tudor arches, Westview Presbyterian Church, Toronto.

The huge United States Navy Ship program gave impetus to the use of laminated wood in the United States during the war. The keels and ribs of minesweepers and other boats were laminated successfully by the use of waterproof adhesives. So successful was the use of these members that glulam construction has been continued in the post-war shipbuilding program. In Canada, wooden minesweepers with laminated supporting members are now being built.

Progress since the war indicates that a new industry is in the making. This demands cooperative encouragement, requires education, training and experience, and needs new standards to effectively further the intelligent use of lumber. It is therefore important that this transition from the handwork stage to that of efficient mechanical production be properly guided by compiling and distributing the best available information on the various phases of the problem.

In Canada the need for such close cooperation in the glulam industry is plainly revealed by the fact that approximately a half dozen laminaters have produced enough "factory grown" timbers to erect upwards of 1,000 buildings since the end of World War II. It is significant that the greater percentage of this production has taken place in the last three years.

Advantages and Limitations

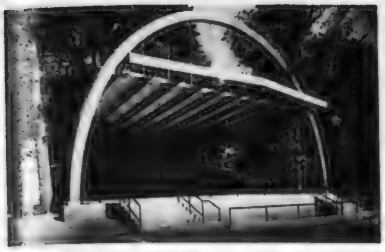
Structural members of a size, shape, and quality that could never be sawn as single pieces from the largest and best trees ever grown are commonplace today.

The preparation of lumber for structural purposes has taken two opposite directions. For many years it has been customary to make smaller pieces from large timbers or logs. Now with the advent of adhesives meeting the requirements of any condition of service, the opposite process of making large timbers out of smaller pieces is growing rapidly.

[1] Presented at meeting of Eastern Canadian Section, Forest Products Research Society, March 4–5, 1954, at Ottawa, Ont.

[2] Numbers in parentheses refer to literature cited.

The Author: Norman F. Smith is a graduate of McGill University, Montreal. Since 1948 he has been employed by Monsanto Canada Ltd. in research and technical sales and service. Smith is a member of the Eastern Canadian Section, FPRS.



Outdoor theatre "Rainbow Stage", Winnipeg, Manitoba.

The advantages of glued-laminated structural members are:

1) Trees too small for the production of large timbers are a source of material for laminated construction, and thus the available supply of material is significantly increased.
2) Laminated timbers can be curved into arches and built with varying cross sections to carry concentrated loads, which cannot be done with solid structural members.
3) With properly scarfed joints in laminates, structural members can be made longer, wider, and thicker than those obtainable from standard solid stock. It is also true that relatively short pieces can be used in certain laminates for standard lengths. Modern gluing techniques develop glue joints in laminated members that are as strong or stronger than solid lumber.
4) Species especially suitable for construction purposes, but which do not occur naturally in large sizes, are rendered available by laminated construction.
5) The moisture content of the lumber can be brought to the optimum level before assembly more easily and more quickly than is possible with sawn timbers.
6) Laminated timbers do not show as much variation in strength, from one to another, as sawn timbers. The natural variability of the species is partially "averaged out" by assembling a number of different pieces to make up a single timber.
7) It is possible to use more than one species in a laminated member, thus taking advantage of the economy of low-strength species and the qualities of a high-strength wood.

The limitations or disadvantages of glued-laminated timbers are:

1) In order to produce a waterproof lamination, the cost of the adhesive may be as much as 12–15 per cent of the total manufactured cost, as shown in Table V.
2) Large buildings and equipment are required to fabricate glued-laminated members.
3) The cost of labor and supervision is higher than some other forms of timber construction, as fabrication techniques must be followed in a precise manner.

A variety of wood species are used in glued-laminated construction. In general, the softwood species have proved satisfactory for general structural purposes. Their low cost, lightness, and strength are all factors which make the softwoods suitable and adaptable for use in glued-laminated timber construction.

In Canada, Douglas-fir lumber is used predominantly, while Western hemlock is employed to a lesser extent. Eastern Canadian softwoods have been experimented with and used to a limited extent. For special applications such as ships' keels, the use of a hardwood species is necessary. White oak is suitable for use in both fresh and salt water.

A glue bond stronger than the wood itself can be obtained in most hardwood or softwood species. Thus the choice of adhesive is governed by the end use rather than the species used.

Method of Fabrication

Although fabrication details will vary somewhat with the individual fabricator and adhesive, the general procedure is as follows:

The lumber is seasoned to the desired moisture content and planed to the required thickness. If the length of the finished member is greater than the length of the lumber to be used, the individual pieces must be made into a laminate of the required length by a scarfed joint. The scarf joint is prepared and the pieces of lumber are glued together prior to laminating the member.

The lamination is run through a glue spreader and then placed on forms arranged to give the desired shape of the member. The various laminations are assembled quickly and the required pressure applied through clamps or jacks.

The laminations are held under pressure until the adhesive has set sufficiently to permit handling without deleterious effects on the glue line.

The assembled member is then removed from the form and the adhesive is allowed to set sufficiently to permit trimming and planing of the surfaces to the desired smoothness or finish. When the glue is fully set, generally several days after assembly, the member is transported to the site and incorporated in the structure.

Sometimes preservative, fireproofing, and surface treatments are applied either before or after gluing the laminations together. This depends upon the compatibility of the adhesive and various chemicals used.

Straight laminated beams, West Glen Public School, Toronto.

Development and Function of Adhesives

Although glued wood panels were found in the tomb of King Tut, the major development of adhesives has taken place since 1900. Prior to then, animal glues were used extensively. However, with the introduction of vegetable glues made from Cassava flour by F. G. Perkins about 1909, a new era in the gluing of wood began. This was simultaneous with the introduction of the first glued laminated structure in Switzerland by Hetzer in 1909.

By 1912 Bakeland had developed a phenolic resin, a synthetic material made basically of phenol and formaldehyde. The Haskelite Corporation developed blood albumin as an adhesive for wood in 1915, and this was followed by the introduction of casein glues in 1917 for use in the aircraft construction industry.

In 1928, I. F. Laucks made a valuable contribution with his development of soybean glues. This was followed by the appearance of urea formaldehyde resin in 1930, a product which did not find large commercial use until World War II.

Shortly after the beginning of the World War II, polyvinyl resins and melamine-formaldehyde resins were offered commercially. By 1943, resorcinol-formaldehyde resin, one of the most expensive of all synthetic adhesives to be developed, was introduced.

All of these glues and resins are being used in varying proportions today in the manufacture of furniture, plywood, boats, and glued-laminated members.

The function of the glue is to hold the parts together under the most extreme conditions of service to which the assembly may be subjected. Therefore, the glue line should be strong and possess a high, reliable, and determinable bond strength, both originally and after prolonged exposure to moisture, dryness, rot, heat, cold, mechanical stresses, sudden shock, vibrations, and any combination of these influences.

High original strength is a requirement of a good glue line. Before an adhesive and a process are chosen for any job of gluing, reasonable evidence should be developed to assure that the strength of the bond will be maintained in service.

Types of Adhesives

Woodworking adhesives vary in their degree of resistance to moisture exposure, in cost, methods of application, and in some cases availability. Therefore the selection of a suitable glue for laminated members is important. For the most part, laminated constructions require high or complete moisture resistance. Thus some types of adhesives such as starch, soybean, and animal glues with low water resistance must necessarily be eliminated for such use. The cure of laminated members is carried on at room temperature or at elevated temperatures of 125° F. to 170° F. by means of a hot chamber. Hot press resins such as melamine-formaldehyde and phenol formaldehyde are unsatisfactory from the standpoint of cure.

Casein glues, urea formaldehyde, resorcinol formaldehyde, and polyvinyl resins remain for the laminater's choice. From a cost standpoint, the polyvinyl resins are midway between casein glues and resorcinol formaldehyde. However, they are in general less water resistant than the casein type. Being thermoplastic in character, polyvinyl resins have a tendency to soften at temperatures above 160° F. and are subject to creep under continual stress.

This discussion on types of adhesives is confined mainly to casein glues and resorcinol-formaldehyde resins, with some remarks on the use of urea-formaldehyde resins.

Casein Glue

This adhesive usually is supplied as a dry powder to be mixed with water immediately prior to use.

Basically, casein glues are made from casein, a material prepared from skim milk by coagulating the milk with sulphuric or hydrochloric acid, or by allowing the milk to sour. The curds thus produced are further processed by washing, pressing, drying, and grinding.

The casein powder is then mixed with chemicals in varying proportions to form the final dry powdered glue. According to the formula employed, the casein glue will exhibit certain properties of mixing, working life, and water resistance, when mixed with water in a ratio of two parts water to one part casein glue. For instance, if the hydrated lime content is increased, with certain limitations, the water resistant qualities of the glue bond increase and at the same time the bonds tend to be more abrasive on the saws or edging tools.

A typical formula is:

Casein	100.00
Sodium fluoride	18.75
Zinc oxide	1.25
China clay	30.62
Bentonite	30.62
Calcium hydroxide	43.75
Water	450.00

Casein glues have found wide acceptance in the laminated construction of arches, beams, trusses, girders, posts, and columns. It is a very versatile glue which can be formulated to provide satisfactory bonds under varying conditions of moisture, temperature, and pressure.

These glues give most satisfactory bonds in a range of 5–15 per cent wood moisture content. It is true that some bonds are formed on laminates running as high as 20–25 per cent moisture, but this is detrimental to the speed of cure and there is a danger that the clamping pressure will be released before adequate tensile strength is attained.

On the subject of moisture resistance of the glue bond, it is generally agreed that casein glues inherently develop a high measure of water resistance over a wide range of moisture conditions. This does not mean that a casein glue is recommended for use in laminated timbers or structures that will be submerged in water or exposed to the weather for any appreciable length of time. However, these adhesives will maintain their high original strength in laminated members used in heated structures such as churches, schools, auditoriums, and industrial buildings where the average equilibrium moisture content does not exceed 15 per cent.

Unheated glued-laminated structures such as barns, skating rinks, and warehouses, under ordinary conditions in the United States and in the temperate regions of Canada, will reach a moisture content of 8–15 per cent. Here casein glues will provide adhesion of excellent durability.

However, there are exceptions such as livestock barns where there is inadequate ventilation, or a skating rink where alternate freezing and thawing takes place frequently. In both cases, the condensation of water vapor exposes the glue line to excessive moisture and in time delaminations will occur as the glue bond softens and weakens under stress while in contact with water.

Laminated structures which may be subject to the previously mentioned conditions should be glued with a completely waterproof resin such as resorcinol-formaldehyde. Decay and fungus growth is also accelerated in excessive humidity conditions and, although some glue manufacturers include a toxic preservative in their formulations, the use of casein glues in very moist locations is not good practice.

The tolerance of casein glue to a wide range of cure conditions, from below to well above room temperatures, is a distinct advantage. Some laminated members are bonded as low as 50° F., but temperatures of around 70° F. are recommended as minimum.

Due to the alkalinity of casein glue, bonding is facilitated with certain oily woods normally difficult to glue such as teak, pitch pine, or yew. Casein glue has better gap filling properties than urea-formaldehyde or resorcinol-formaldehyde resin.

Urea-Formaldehyde Resins

Urea-formaldehyde resins came into prominence during World War II and since 1945 have been used extensively in the furniture and plywood industry. Their manufacture is based on the reaction between carbon dioxide and ammonia. The urea thus formed is combined with formaldehyde and other chemicals to form a resin which can be packaged and sold in either liquid or powder form.

These resins can be used as either cold press or hot press adhesives and display varying degrees of water and fungi resistance, depending directly on their formulation. They are generally mixed with fillers or extenders immediately prior to use as an adhesive, and catalysts or hardeners are also added to govern the "pot life" and the rate of setting.

Hot pressing of urea resins will not be discussed at this time other than the fact that they are set at temperatures ranging from 240° F. to 260° F. Due to the size and shape of laminated members, it is impractical to design hot presses for this task. However, it is practical to use cold setting urea resins for laminating structural members, although distinct disadvantages have been experienced and will be explained later.

When urea resins are used as cold setting adhesives (70° F. minimum temperature) they usually contain approximately 10 per cent wood flour or shell flour or are extended with 25–50 per cent cereal flour. At the time of mixing, a catalyst or hardener is added which immediately begins to lower the pH of the resin-filler-catalyst combination.

The time taken for the mixture to thicken to a point where it can no longer be used satisfactorily in spreading equipment is called the "working life" and in general is approximately 4 hours at 70° F. As the temperature of the resin mixture increases, the working life decreases and the cure time decreases, providing the same adhesive formulation is used. It is, therefore, always beneficial in production to keep the temperature of the resin mix as close to 70° F. as possible to enjoy the

maximum working life. At the same time, the cure temperature may be increased by means of a hot chamber or hot tunnel to decrease the curing cycle.

Urea resins are less tolerant to the wide range of moisture conditions, temperature, and pressure, than the casein glues. For instance, wood moisture content of greater than 10 per cent in hot press gluing and 14 per cent in cold press gluing provides poor gluing conditions for urea resins. The resulting bond strength will verify this point. On the other hand, satisfactory glue bonds can be obtained with casein glue up to 15 per cent or slightly higher. Below temperature of 70° F., the chemical reaction between the catalyst and urea-formaldehyde resins is not complete, the glue line is weaker than normal and maximum water resistance is not obtained. Casein glue, not depending on a chemical reaction wholly for cure, will give satisfactory glue bonds at 60° F. Pressures must be sufficient to give intimate contact between the two surfaces to be bonded when urea resins are employed, as they are not as "gap-filling" as the casein.

In summing up, urea resins have not gained the popular demand in the laminated construction field that casein glues have acquired. According to results of exposure tests on laminated beams by the U. S. Forest Products Research Laboratory (21), "most forms of urea-resin glue are moderate to low in resistance to exposure at high humidities and ordinary temperatures and low in durability under conditions involving high temperature, especially to combinations of high temperatures and high humidities."

The report further states that, "In resistance to exposures involving high temperatures, the superiority of casein over room-temperature-setting urea resin is clearly shown. When service conditions involve occasional or frequent soaking in addition to high temperature and extreme humidity exposures, neither casein nor room-temperature-setting urea glue appears to be satisfactory." These factors, with those of temperature of cure and pressure, make the urea-formaldehyde resins a little more difficult to employ with complete satisfaction.

Resorcinol-Formaldehyde Resins

The resorcinol-formaldehyde resins as adhesives provide the only commercially accepted materials which develop a completely waterproof bond by the cold press method. Their limited use in the woodworking field stems from their high cost, which is in the neighborhood of 55 cents per pound as compared with 8 to 12 cents per pound for casein glues and urea-formaldehyde resins.

HB beams continuous rigid frame, 2—40 ft. spans with outstanding legs, Watertown, Ontario.

The resin is manufactured by heating resorcinol, a white crystalline solid, with formaldehyde as a 37 per cent solution in water. The reaction is brought to completion with a deficiency of formaldehyde and is sold in this state as a reddish brown syrup with good stability.

The resorcinol-formaldehyde resins are prepared for use as adhesives by the addition of fillers to adjust viscosity, and formaldehyde as the catalyst to complete the reaction. The chemical reaction commences immediately at the time of mixing and the working life of the mixture is approximately four hours at 70° F.

It is imperative that resorcinol resins be cured at temperatures of 70° F. or higher, preferably 75–85° F. if possible. Limited laboratory work has indicated that resorcinol resins develop much higher bond strength at a cure temperature of 110° F. than at 70° F. This, of course, would require a hot chamber.

On oak, some fabricators indicate that glue line temperatures of 140° F.–170° F. must be attained to obtain maximum bond strengths. Radio-frequency dielectric heating may be employed to cure the glue in sizeable structural timbers.

These resins are used successfully on a wood at a moisture content ranging from 6–15 per cent. At moisture levels above 15 per cent, the cure is slow, the glue line seems to "wash out", and poor adhesion is experienced.

Modifications of resorcinol-formaldehyde resins have been made with phenol to lower the cost of the adhesive. This reduces cost by not more than ten cents per pound, but also lessens the tolerance on minimum cure temperature to 85° F. It is not, therefore, recommended unless some system is installed to elevate the normal room temperature to 85° F. or preferably higher, and thus provide a satisfactory curing temperature.

Technique of Gluing

The proper technique of gluing with each adhesive is carefully developed by its manufacturer. Certain rules are outlined here on the use of adhesives in laminated structural members. Each manufacturer's instructions should be carefully followed, as different brands of even the same type of adhesive may require quite different mixing procedure, assembly time, and curing conditions.

Preparation of Lumber

All surfaces to be joined by gluing should be finished or machined; rough lumber should not be used.

The pressure applied to the timber during gluing will, to some extent, provide close contact between laminations with surface irregularities. Such irregularities should be kept to a minimum, as excessive pressures may be required to give complete contact between laminations which, in turn, may result in crushing the wood fibers in adjacent areas.

In order that the adhesive may produce its expected bond strength, the surface of the wood must be free from grease, dust, and dirt.

Studies on a series of shear tests, undertaken at the Forest Products Laboratories Division, Ottawa, to determine the relative gluability of various surface conditions on three species of wood, yielded some interesting results. Douglas-fir, spruce, and pine were glued together in various combinations with both planed and sawn surfaces.

The investigation indicated that the quality of glue joint, insofar as surface conditions and species combinations were concerned, could be listed in descending order as follows:

a) Planed to planed surfaces
b) Planed to sawn surfaces
c) Sawn to sawn surfaces

Moisture Content

The moisture content of the wood to be glued plays an important part in the stability and effectiveness of the joint.

The casein glues are probably the most tolerant to wood moisture content of any of the three adhesives mentioned (casein, urea-formaldehyde, and resorcinol-formaldehyde). They provide glue bonds of excellent strength on wood with 5–15 per cent moisture content, and it is known that they can bond wood to wood with moisture content as high as 20 per cent with moderate success. They depend mainly upon the diffusion of the water from the glue line for their cure.

However, with the synthetic adhesives (urea-formaldehyde and resorcinol-formaldehyde), the level of moisture content seems to affect the curing of the bond and ultimate bond strength to a greater extent than with the casein glues. This is mainly because the curing of synthetic adhesives is a chemical reaction and therefore sufficient moisture must be present in the wood to serve as a vehicle to facilitate glue penetration. Lack of moisture results in shallow penetration of the glue into the wood and consequently the joints are weak. Excessive moisture, on the other hand, causes too much penetration and a "starved" glue line may result.

The lumber should be kiln-dried or air-seasoned to a suitable moisture content according to the anticipated service conditions and the type of glue that will be used. It is recommended that the manufacturer of laminates refrain from the use of green lumber for laminated members. It is also recommended that the lumber be dried to the expected service moisture content before assembly.

The atmospheric requirements for a fixed moisture content are shown in Table I. Moisture content, i.e., the weight of water contained, expressed as percentage of oven-dry weight is best determined by the oven-dry method. This method is as follows:

> Samples approximately 1 in. long are cut in the direction of the grain from representative boards. Samples are weighed immediately, before any drying takes place. They are then heated in an oven at 212° F. to constant weight. The difference between the original weight (W_o) and the oven-dry weight (W_d), divided by the oven-dry weight, and multiplied by 100 is the percentage of moisture.

$$\frac{W_o - W_d}{W_d} \times 100 = \text{moisture content, per cent.}$$

Working life (pot life) is the period of time during which the adhesive is usable. The temperature of the room affects working life. An adhesive that has a working life of 4 hours at 70° F., may only have 1½ hours at 90° F.

The pot life of a resin glue mix may be extended by a cold water bath around the container. In most cases, the mixed adhesive is usable as long as it is sufficiently fluid to pour and spread properly. Table II outlines the effect of glue temperature on "pot life".

Table I.—ATMOSPHERIC REQUIREMENTS FOR FIXED MOISTURE CONTENT

Dry Bulb Tem. °F.	Equilibrium Moisture Content of Wood					
	10% m.c.	12% m.c.	15% m.c.	10% m.c.	12% m.c.	15% m.c.
	Wet Bulb Temperatures Degrres F.			Relative Humidity of air		
60	51°(—9°)	53°(—7°)	55°(—5°)	55%	65%	75%
70	60°(—10°)	63°(—7°)	65°(—5°)	55%	68%	77%
80	69°(—11°)	72°(—8°)	75°(—5°)	57%	68%	78%
90	78°(—12°)	81°(—9°)	84°(—6°)	58%	68%	78%
100	87°(—13°)	90°(—10°)	94°(—6°)	60%	68%	80%
110	96°(—14°)	100°(—10°)	104°(—6°)	60%	70%	80%
120	106°(—14°)	110°(—10°)	114°(—6°)	62%	72%	82%
130	116°(—14°)	120°(—10°)	124°(—6°)	65%	73%	83%
140	126°(—14°)	130°(—10°)	134°(—6°)	65%	75%	85%
150	136°(—14°)	140°(—10°)	144°(—6°)	67%	75%	86%

Numbers in parenthesis are wet bulb depression below dry bulb.

Table II.—GLUE TEMPERATURE VS. WORKING LIFE

Glue Temperature (°F)	60	70	75	80	85	90	95	100
Pot Life (Hours)								
a) Resorcinol-Formaldehyde Resin	5	3–4	3	2½	2	1–1½	1	¾
b) Casein Glue	10	6–8	--	3–4	--	2	--	1

Glue Spread and Cost

The adhesive can be spread on the laminates by a brush or mechanical spreader. In most cases the mechanical spreader is used in order to provide a glue film of equal thickness over the entire gluing surface. Generally a light coating of glue applied to both faces of each lamination is better than a heavy coating applied to one face only.

Many factors, such as porosity of wood, moisture content of wood, temperature of wood, and type of glue, affect the ultimate pounds of adhesive spread on the surface of the wood. In general, the figures shown in Table III will act as a guide.

Table III.—RANGES OF GLUE SPREAD

Type of Glue	Softwood	Hardwood
Resin Adhesives	40–60 lbs.	35–50 lbs.
Casein Glue	55–75 lbs.	50–60 lbs.

The chief factors which affect the cost of the adhesive are the gross glue spread, the size of the laminated member, and the type of adhesive. For instance, Table V provides an interesting comparison between the cost of casein glues and resorcinol-formaldehyde resins. The figures shown are in percentages of the total raw material cost of the laminated member.

Table IV.—GLUE SPREAD TESTS

Lbs. Liquid Mixture per 1000 Sq. Ft.	Ounces per Sq. Ft.	Grams per Sq. Ft.
30	.48	13.6
35	.56	15.9
40	.64	18.2
45	.72	20.4
50	.80	22.7
55	.88	25.0
60	.96	27.2
65	1.04	29.5
70	1.12	31.8
75	1.20	34.1
80	1.28	36.3
85	1.36	36.6
90	1.44	40.9
95	1.52	43.1
100	1.60	45.5

Table V.—COST OF CASEIN GLUE VS. RESORCINOL–FORMALDEHYDE RESINS AS A PERCENTAGE OF THE TOTAL MANUFACTURED COST OF THE MEMBER

Size of Laminated Member	Type of Adhesive	
	Casein	Resorcinol-Formaldehyde
3¼" x 8⅛" x 16'	1.33%	7.40%
3¼" x 14⅜" x 16'	1.89%	10.50%
5¼" x 19½" x 16'	2.22%	12.35%
7" x 21⅛" x 16'	2.32%	12.95%
9¼" x 26" x 16'	2.50%	14.00%

The ratio of the glue line to the foot board measure of the member increases with the size of the member. The glue cost increases proportionately as the ratio increases.

The question is often asked "how much does it cost for the adhesive used in manufacturing laminated arches for a church?". The best way to answer the question is to take an example of a typical church construction, as follows:

Type of Arch—Tudor
No. of Arches—5
Span—40 feet
Spacing—on centres 15' apart
Wall leg—10 feet high
Roof leg—Slope of 12 on 12
Width of Arch—5¼ inches
Heel of Arch—12 inches
Crown of Arch—10 inches
Type of Glue Used—Casein
Glue Spread—60 lbs. per 1000 sq. ft. of single glue line
Total Glue Used Per Arch—80 pounds of wet glue mix
Total Glue Used for 5 Arches—400 pounds
Total Cost (at $8.50 cwt)—$34.0

In curved arches, the cost of the adhesives is generally higher than on straight beams. This is due mainly to the increased number of laminates per member and to the excess wastage of glue due to the increased number of square feet of glue line per lineal foot

of member length. In curved arches, the maximum thickness of the laminate is ¾ inch, while on straight beams 1⅝ inches is a common thickness.

Assembly Time

The time allowed between the spreading of the glue and application of gluing pressure will vary with the type of glue, moisture content of the wood, temperature of the surrounding air, and thickness of the glue spread.

In general, the assembly time should not exceed more than 20–30 minutes. However, in certain instances where the construction of the laminate limits the speed of assembly, excessive spreads can be used, and hence the assembly period lengthened by 10–15 minutes. This latter technique is not recommended for the development of high quality bonds.

Pressure

The object of pressure is to bring the surfaces to be glued into intimate contact.

Some adhesives require more pressure than others. For instance, synthetic resin adhesives of the urea-formaldehyde and resorcinol-formaldehyde types, require more pressure than casein glues in order to develop equal wood shear strength.

Some species of wood require more pressure than others. Suggested minimum gluing pressures are shown in Table VI.

Table VI.—RECOMMENDED GLUING PRESSURES

Type of Glue	Softwoods p.s.i.	Hardwoods p.s.i.
Casein	100	150
Resin Glues	150	200

Pressure should be applied by screw jacks or clamps. The pressure should remain on the laminations until the glue "squeeze out" is hard or until the bond has attained sufficient strength to resist any tendency of the laminations to spring apart after the pressure is released. In curved members, it is better to extend the pressure period slightly longer than is recommended for the straight members, to insure against the possibility of delaminations.

Nail pressure has been used in the past but is not recommended in general practice. Tests clearly demonstrate the superiority, with respect to both strength and stiffness, of glue over nails as a means of joining laminations. Experience, tests, and observations show that nails decrease in effectiveness with fluctuations in the moisture content of the material nailed. Tests made after a period of service under the usual conditions would no doubt be still more favorable to glued construction.

The pressure period varies considerably according to the temperature of cure, the glue spread, size of member, and species of wood. It is therefore difficult to recommend the specific clamping time required unless the exact conditions are known. Table VII indicates the effect of glue line temperature on clamping time using resorcinol-formaldehyde resin. Glue-line temperature is not to be confused with glue-room temperature.

Table VII.—GLUE-LINE TEMPERATURE VS. CLAMPING TIME

Glue-line Temperature	Clamping Time (in hours) Resorcinol-formaldehyde Resin
70°F	7 –8
80°F	4 –4½
90°F	2 –3½
100°F	1½–2
110°F	¾

Outlook for Future

In order to build the glued-laminated timber construction industry on a firm foundation for the future, it is necessary to consider the past performance of existing laminates to estimate future raw material supply, to utilize available technical information on fabrication, and to determine future demand of the product.

T. R. C. Wilson of the U. S. Forest Products Laboratory several years ago made a detailed study of about 50 European laminated structures. He reported that observations pointed to long life for laminated members in buildings. His investigation included the examination of a foot bridge over a railway track in Adolfsburg, Sweden, built in 1923, a tower about 50 feet square on the University at Zurich, Switzerland, built in 1913, and a hangar at the Military Flying Field, Douvendorf, near Zurich, Switzerland. He stated: "Lack of examples of members that have failed or have seriously deteriorated under such exposure during the third of the century of the history of this type of construction precludes any but optimistic estimates of length of life and permanence" (7).

In the United States and Canada, the laminating industry is so new that enough time has not elapsed to indicate the durability of adhesives of the existing structures. However, each succeeding year yields more durability data on glues and gradually there will be an accumulation of information which will serve as a guide for future development work.

Recently in Canada there has been formed an association called "The Canadian Institute of Timber Construction." One of its purposes is to plot the course for the future development of the laminating industry and to guide it to a successful future.

In 1953, the Canadian Standards Association printed CSA 0122—1953, a specification for glued laminated timber construction. This specification covers the requirements for the design and construction of glued-laminated timbers and for the testing of the glue bonds to determine their strength and resistance to moisture.

The methods of testing bonds are intended for determining the quality and durability of the bond in laminated members. For this purpose, the tests are governed by the degree of exposure to which the member is to be subjected. However, when it comes to end use of the laminated product, there is little control over the matter of choice of glues, especially in borderline cases such as the construction of skating rinks, laundries, and barns. Here it is the laminater who decides whether a casein glue or a resorcinol formaldehyde resin should be used. At present there is no control over his choice, except his desire to maintain a high reputation in laminating business.

It is suggested that perhaps the new Canadian Association can in some way prevail upon the industry to become organized in such a manner that they will be able to identify glue-laminated members. Identification should be made on the type of glue used, the specification it passes, and the end use. Some type of policing or inspection service set up by the Association may be necessary.

All executives responsible for industrial planning and construction should thoroughly investigate the possible use of glued-laminated construction. It has reached a stage of development that, when well fabricated with proper materials, there can be no doubt as to its usefulness, adequacy and dependability.

Bibliography

1. Morrison, F. C., Kennedy, D. E., and Bergin, E. 1950. Strength tests on glued laminated beams. Canada, Forest Products Laboratory, Mimeo 113.
2. Kennedy, D. E. 1951. Glued laminated construction. Canada, Forest Products Laboratory, Mimeo 0–117.
3. Hanrahan, Frank J. 1943. Glued laminated timber construction. Mechanical Engineering 65 (12).
4. Ketchum, Verne. 1944. New uses of glued laminated timber structures. Conference report on new developments in wood products. N. Y. State College of Forestry. Oct. 687.
5. Dixon, Harold F. 1950. Wood adhesives. Proc., Forest Products Institute of Canada.
6. Kennedy, D. E. 1950. The construction and testing of a glued laminated wooden arch of 47 foot span. Canada, Forest Products Laboratory, Mimeo 0–152.
7. Wilson, T. R. C. 1939. The glued laminated wooden arch. U. S. D. A. Tech. Bull. 691.
8. Truax, T. R. 1929. The gluing of wood. U. S. D. A. Dept. Bull. 1500.
9. Oliver, W. A. 1941. Tests of glued laminated wood beams impregnated

with creosote. Proc., American Society for Testing Materials. 41:1198–1213.
10. Wilson, T. R. C. 1935. Latest developments in glued-arch construction. American Lumberman 40:46–47. No. 3063.
11. Schrader, O. H. 1943. Effect of grouped scarf joints in clear, laminated, glued beams of Douglas fir and Sitka spruce. The Timberman 44:49–50, 52, 54, 57.
12. Anon. 1940. Glued laminated structural members. The Washington State Engineer 14:2–9.
13. 1942. America's longest laminated timber arches for Northwest Airlines hangar. Engineering News Record 128: 168.
14. deBruyne, N. A. 1940. Why does glue stick? Wood (London).
15. Anon. 1941. Glued laminated wood arch footbridge. Mississippi Valley Lumberman (Minneapolis) 72:31.
16. Kahn, H. S. 1943. Laminated arches. Wood (London) 8:30–32.
17. Clear span trusses for barns, halls, garages. 1943. American Builder 65:54, 70.
18. Chapel arches for the army camps. 1942. The Timberman 143:22.
19. Timber plate girders are light and economical. 1953. Canadian Builder. Holliday Publications, Ltd., Montreal.
20. Bergin, E. G. Glues and gluing. Canadian Woods, Their Properties and Uses, Chap. 10. Queen's Printer, Ottawa.
21. Summary of information on the durability of water-resistant woodworking glues. Rev. Dec. 1946. U. S. Forest Products Laboratory Report 1530.
22. Selbo, M. L. and Olson, W. Z. 1953. Durability of woodworking glues in different types of assembly joints. Jour. FPRS III (5):50–60.
23. Increasing the durability of casein glue joints with preservatives. U. S. Forest Products Laboratory Report 1332.
24. Freas, A. F. and Selbo, M. L. 1954. Fabrication and design of glued laminated wood structural members. U. S. D. A. Tech. Bull. 1069.

Wood and Metal Combinations[1]

PAUL H. McCORMACK

Development Engineer, Alexander Research Laboratories, National Adhesives, Plainfield, New Jersey

A variety of bonding methods and adhesives will produce good, serviceable bonds in laminating metal to wood. Various bonding methods, resins, bonding procedures, and conditions are discussed.

GREAT PROGRESS IN METHODS of bonding metal to wood has been made in the past 15 years.

The earliest wood to metal laminations were primarily mechanical ones, a system still used when service and appearance considerations are of little or no importance. Mechanical fastening of metal to wood is readily accomplished by means of nails, screws, and clenching a wood core by folding a metal skin around the edges. These methods possess many drawbacks, in appearance and performance of the finished panel.

The classic method of fastening metal to wood has been the employment of heavy cohesive mastics of either rubber or asphaltic composition. Materials of this type suffice where severe service conditions, such as elevated temperatures or long-term aging, are of little or no importance.

In recent years, a great deal of research has been devoted to rigid bonding of metal to wood in order to take advantage of the blending of structural properties inherent in both elements of the lamination. Better bonds than those produced by mechanical or mastic fastening are now available. However, it is doubtful that even these represent anywhere near the ultimate in adhesive properties obtainable. Research efforts in many branches of industry are continually contributing new methods and information on this most difficult phase of adhesive technology.

A wide variety of bonding methods is now available, offering a choice of thermoplastic, thermosetting, and thermoplastic-thermosetting materials for metal to wood lamination.

For purposes of simplicity the previously mentioned classes should be outlined separately.

Thermoplastic Bonding

This is an extension of the mastic or cohesive principle in bonding dissimilar surfaces. An unbalanced construction (simple bonding of a sheet of metal to a wood or plywood core), can be constructed by coating each of the surfaces with a thermoplastic material such as a polyvinyl acetate, a plasticized polyvinyl acetate, a formulated rubber cement, or a hot melt type of adhesive, allowing solvents to escape if necessary, and then bonding the two dissimilar surfaces together by means of pressure or a combination of heat and pressure.

The adhesion (more accurately cohesion) results from the flowing together of the adhesive surfaces. These bonds, while adequate for many structural and decorative purposes, are limited in performance, especially in regard to durability at elevated temperatures, due to the very nature of the resins employed. However, they do possess the desirable properties of adhering rapidly and being relatively simple to use.

Most thermoplastic materials possess a high degree of chemical resistance. Their resistance to certain solvents and solutions is good and as a result they are employed as bonding agents for laminated household tile, enamel steel panels in roadside diners, gas stations, etc. They at best represent a compromise between crude methods of bonding with mastics and the more durable bonding achieved with more rigid materials.

Their acceptable performance in normal exterior exposure to temperate climates is due to the ability of the adhesive to compensate for the expansion and contraction induced by hot-cold or wet-dry conditions. They are nearly always given auxiliary support, either by lapping the edges of the metal decorative surface over the edge of the core or by insertion in a channel iron support or "I" beam type of divider which imparts mechanical rigidity to the entire structure and compensates for any shifting or inequalities and variations brought about by the influence of moisture or temperature under normal service conditions. Panels of this nature have been known to "dish" or buckle severely when improperly mounted or when used under conditions where they could not normally be expected to perform to best advantage.

Thermosetting Resins

Engineers who deal with problems of elevated temperature and structural strain coupled with vibrations of relatively small amplitude but high frequency, typical of aircraft and trans-

[1] Presented at a meeting of the Northeast Section, FPRS, Nov. 4–5, 1954, in New York City.

The Author: Paul H. McCormack attended Polytechnic Institute of Brooklyn, has worked in laboratory and field development of wood adhesives and allied products at National Adhesives Research and Development Laboratory since 1947. A charter member of FPRS, McCormack has authored numerous articles and company manuals.

portation equipment, usually employ thermosetting resins. Many materials have been explored as aircraft cores, among them paper honeycombs, balsa wood end-grain cores, molded plywood, and hardwood plywood.

Advances have been made both in adhesives and in the technology of bonding dissimilar materials for the aircraft industry, but there has been an understandable hesitancy to plunge into bonding of this nature until adequate performance records have been accumulated. In the absence of adequate nondestructive testing procedures, the final bond is always subject to doubt.

Another example of thermosetting bonding can be found in the structural panels used in railroad passenger coaches. These panels provide the warm, decorative appearance of wood veneers and also impart better acoustical properties to metal panels so sheathed. Truck bodies have been made with metal faced plywood and railroad cars have been lined with metal faced plywood. In both instances, metal faced plywood is used because of the high strength to weight ratio obtained in addition to the improved mar resistance of metal surfaces. A clad plywood surface is undoubtedly superior to a plywood surface alone for this use.

A more ingenious employment of metal to wood laminations with thermosetting resins is the manufacture of jig, template, and layout plates for precision work. A laminate of this type possesses greater rigidity than a metal sheet and is much lighter and cheaper than a metal plate of equal thickness. Manufacturing operations such as pattern making, die layout, etc., consume a large amount of metal to wood laminates.

A well known thermosetting resin system for bonding metal to wood is the Redux process, a British development which has seen considerable service in the automative and aviation industries. This is essentially a two-part thermosetting adhesive system employing a phenol formaldehyde resin coated on the metal surface, precuring the phenol formaldehyde resin to a tacky stage, and then dusting with a powdered co-polymerizing accelerator which contributes cohesive properties. Bonding is obtained through the use of heat and will not occur at room temperatures, a procedure which limits its wide acceptance. Unbalanced constructions are impractical due to the temperatures necessary (285–350° F. for 15 minutes).

Epoxy resins have been used in the 100 per cent reactive paste and in solvent solution form to bond metal to wood. This particular class of resins is distinguished by its ability to cure either at room temperature or at elevated conditions and at low pressure. Extremely strong in both tension and compression shear, unmodified epoxy resins have peel strengths which are considerably less than that obtainable in true compression shear. Whether or not a peel test is adequate for determining the usefulness of a metal to wood laminate is subject to some question, and it may well be that these resins will be more acceptable in the future than they are at the present stage of development.

Polyester Resins

These resins display relatively poor adhesion to metal when compared to other adhesives and have a disappointing tendency to penetrate away from the bonding area during the curing cycle.

Resorcinol Resins

These resins are distinguished by their exceptional resistance to both elevated temperature and severe chemical and solvent action. They are excellent adhesives in wood to wood bonding and are employed in bonding metal to wood. However, it is always necessary to prime the metal surface with a cohesive type of primer in order to effect a bond of reasonable strength. Since the metal priming materials are nearly always thermoplastic in nature (casein-latex) many of the advantages of resorcinol are lost since the adhesive is limited by the service conditions of the primer.

Emulsion Adhesives

Casein-rubber latex adhesives have been used for many years as adhesives for metal to wood. The glue line can be cured at room temperature or an accelerated cure can be obtained with a hot press. The bond has poor water resistance and relatively low strength. Casein-latex is often used as a primer in resorcinol bonding procedures.

Newcomers to the field of metal to wood bonding are the thermosetting vinyls and thermosetting epoxy-amine emulsions. The thermosetting vinyls, in emulsion or solution form, are used to limited extent for bonding metal to wood with apparently excellent results. This method utilizes phenolic type copolymerizing agents for vinyl acetates in emulsion form.

These adhesives are distinguished by the need for formulation before use. This usually entails the addition of a urea formaldehyde or phenol formaldehyde solution to the vinyl acetate emulsion, then bonding with heat and pressure to obtain cross linking. This copolymerization reduces the creep characteristics found in many polyvinyl acetate materials.

Thermosetting epoxy-amine emulsions are being used because of their ability to bond many varied surfaces including metal and wood. They are supplied as two emulsion components mixed some time prior to use. They can be applied by all conventional glue spreading methods.

Among their principal advantages are: the absence of the need to prime metal surfaces prior to bonding, exceptionally long pot life, and the ability to cure equally well at room or elevated temperatures. Preparation before use is simplified by supplying the two components in a form which requires mixing equal parts by volume. Precise weighing is eliminated. Epoxy-amine emulsion can be best applied by spreading on the wood core. The absorbent wood surface acts as a filter separating the reactive resins from the water phase of the emulsion, thus insuring that the resin remains at the adhesive surface rather than saturating the wood substrate with expensive bonding materials.

Emulsion adhesives, particularly the amine types, are characterized by their property of producing the same adhesive strength whether cold pressed or hot pressed. The elimination of a hot pressing operation is a decided advantage in avoiding cupping of the final laminate.

Epoxy-amine emulsion adhesives are also distinguished by their ability to withstand elevated temperatures and yet retain sufficient flexibility to permit bending operations subsequent to forming the lamination. They also retain a high degree of resistance to acids, alkalis, and water at elevated temperatures.

Bonding Procedures

Metal to wood bonding rarely requires that any extensive procedures be employed for preparing the wood surface other than those commonly employed in conventional laminating techniques. The surface should be clean, freshly scraped, or sanded (scraped surfaces appear to produce better bonds than sanded surfaces). The core face should be of good quality to prevent any irregularity of the core face "telegraphing" or "printing" through to the metal surface since such disfigurement cannot be removed by normal polishing techniques after lamination. To insure against blemish, cores should be cleaned with an air blast or brushed prior to actual glue spreading and lamination.

Preparation of the metal surface is the most critical factor in satisfactory metal to wood bonding. For most adhesives it is necessary to completely degrease either by vapor degreasing or acid bath etching, preferably a combination of both. Since both acid etching and solvent degreasing can seldom be performed economically, solvent degreasing is the more commonly employed method. Degreasing with chlorinated hydrocarbons in a vapor de-

greasing system appears to be the ideal method of insuring complete removal of residual grease, finger prints, rolling compounds, paints, and inks.

All metal surfaces should be tested for cleanliness by the water-break method prior to use. It is conceivable that under well regulated conditions this test could be used only as a spot check on operations. However, the high cost and the high performance requirements of such laminates usually justify intensive quality control in this phase of the lamination procedure.

The bonding of some metals, such as aluminum and copper, usually requires electrolytic etching prior to bonding in order to insure that the surface be adequately wetted by the adhesive. Phosphatizing of steel is desirable, although not absolutely necessary.

Many of the adhesive systems described require the separate application of one or more components of the adhesive system prior to combining. This is generally true of the cohesive rubber cements, the Redux system, and in bonding with solvent solution epoxy resins. Since this operation constitutes two separate glue spreading operations, it is usually more effectively accomplished by means of spray application since the dissimilarity in thickness of metal skin and the wood core precludes the use of a single glue spreader for one operation. If two glue spreaders can be employed, they will out produce a hand sprayer. However, it appears that reciprocating flat bed sprayers with mechanical feed can be employed when the operation is of sufficient volume.

Bonding Conditions

Bonding conditions vary widely, depending upon the type of adhesive chosen for the lamination, ranging from contact pressure which generally suffices for bonding with mastics, thermoplastics, and rubber cements. The epoxy resins bond best at low pressures. Higher (50–125 psi) pressure bonding must be employed with Redux, resorcinol, catalyzed polyvinyl acetates, and epoxy-amine emulsions.

Those adhesives which cure at low pressures are usually suitable for vacuum bag molding where the overall pressure seldom exceeds 12 to 13 psi. At room temperature the laminate is usually of suitable quality and is generally free from printing or telegraphing of core irregularities to the metal surface. When bonding under high pressure in a cold or hot press (30–100 psi), a considerable degree of control must be exercised over the quality of the core in order to avoid the possibility of telegraphing irregularities through the metal surface.

It is most important in any procedures that require heat to avoid excessive or prolonged heating due to the considerable disparity between the coefficients of thermal expansion of most metals contrasted to the heat stability of wood cores. The shrink characteristics of metal being omni-directional, it is not unusual for an unbalanced lamination to dish or cup excessively on cooling to the point where it is useless for structural purposes.

Where a high degree of flatness is necessary (this condition prevails in nearly all structural members) cold bonding is most desirable. Since this can only be effected through the use of adhesives which will cure to a high shear strength within an economical period of time, the choice of adhesives is definitely limited to resorcinol, the catalyzed vinyl acetates, and epoxy amine emulsion adhesives.

In cold pressing of metal to wood, the amine emulsion types stand out for their combination of long pot life in liquid form and relatively short room temperature cure cycle. An adhesive of this type has been known to remain usable for as long as 7 days with no apparent degradation of bond strength. While this is, at the present stage of development, considered to be an abnormally long pot life, pot lives of 24 to 48 hours are not unusual. The emulsion material referred to here will cure to 75 per cent of final strength at 70° F. within 18 hours at 70 psi. This condition compares very favorably with resorcinol bonding. In addition, it is exempt from the limitations imposed by temperature sensitive priming materials commonly employed with resorcinol.

Bending Metal to Wood Laminates

As stated previously, temperature control is important in insuring the flatness of metal to wood lamination. This point is stressed largely because these laminations are employed as flat structural components in most usages.

In normal metal clad construction, where curves are required they are usually accomplished by a metal molding or insert to insure a smooth curve with the least amount of fabrication expense. It is possible, however, to apply most metal forming operations to metal to wood laminations if certain characteristics are kept in mind, particularly where sharp radius bends or folds must be utilized in the final construction.

On cores over 3/16-inch thickness, bends of less than 4-inch radius usually result in severe collapse of the wood surface or a rupture of the glue line in the vicinity of the bend. Where core thickness is in excess of 3/16-inch or where tighter radii are employed, it is necessary to remove a portion of the wood backing by slitting at intervals along the periphery of the fold. Folds approaching 90° can be accomplished if proper caution is taken. However, in most operations it is also necessary to back up the fold with a glued-in doubler of wood, or in the case of sharp bends, the insertion of a glue block similar to that employed in normal wood furniture construction.

The previously mentioned conditions also apply where the metal surface is to become the interior of the fabricated article. If proper precautions are not taken, the resulting article will be extremely undesirable from both the service and appearance standpoint due to tension failure in the wood structure, especially where severe radii are employed. Normal procedure would require that careful slitting be done prior to bending and that a doubler or cover for the bent area be applied at the time of fabrication. For this purpose, any wood adhesive consistent with the service requirements of the finished article can be employed.

Summary

There are materials available today to bond metal to wood which produce good, serviceable bonds. These metal-clad materials will exceed the performance of wood alone in regard to chemical resistance, abrasion resistance, and mar resistance. The manufacturer faced with the problem of bonding metal to wood can at the present time draw upon the resources of America's adhesive technologists in order to produce serviceable and useful metal to wood laminations.

Gluing Hardboard to Fir Plywood with Phenolic Resin Adhesives[1]

ALAN L. LAMBUTH

Plastics Division, Monsanto Chemical Co., Seattle, Wash.

Series of tests were conducted to study factors affecting adhesion of hardboards to fir plywood and relative merits of phenol resin adhesives compared to other types of plywood glues. Conclusions are based on modification of conventional knife test.

PHENOL-FORMALDEHYDE plywood glues, by virtue of their low cost and impervious bond, make possible the exterior grades of plywood used today. Phenol-formaldehyde resins are not the lowest cost plywood adhesives, nor the fastest setting, nor even the most trouble-free. But they represent the most successful compromise of speed, durability, and cost yet developed for bonding weatherproof plywood. Modifications and combinations of phenol-formaldehyde resins with other materials will continue to be made, but it is our opinion that the resins themselves will be the basis for exterior type plywood bonds for some time to come.

Because phenolic resins are such an integral part of the plywood industry, it is necessary to evaluate carefully their connection with major changes in the industry. Such a change is now at hand, with the advent of hardboards of various kinds replacing wood veneer as the face stock for Douglas-fir plywood.

Since a first step in a situation of this sort is to evaluate existing products for use in a new combination of materials, the Monsanto Chemical Co. has been conducting a series of adhesion tests on each new hardboard as it is marketed. The following discussion of hardboard gluing is based on this firm's tests of phenolic plywood glues in bonding hardboards to Douglas-fir plywood.

New Test Method

Test results obtained by existing shear test procedures were not found to be sufficiently critical of adhesion, so a new method was developed which better compared bond strengths. This new method is a modification of the conventional knife test, which causes failure in tension rather than shear. It was reported in the August, 1954, FPRS JOURNAL.

Test results from this method were used as a basis for the conclusions which follow. It was considered to be in the best interests of the plywood industry to base the findings on the more severe method of testing. Figure I shows a typical comparison of knife and shear test results from ¾ inch Plyron bonded with a phenolic adhesive.

As a general rule, any phenolic plywood glue will bond any standard grade of hardboard to fir plywood in a satisfactory manner. However, only a few of the treated hardboards (tempered, high surface resin content, etc.) can be glued satisfactorily with phenolic adhesives. Exterior grade Plyron is difficult to make as a result, and almost invariably requires an additional machining process on the hardboard, such as sanding or planing, to improve its bonding properties.

It is ironical to note that the exterior grade of hardboard can be glued easily with many interior plywood glues which in themselves are unsuitable for outside exposure. Until a solution is found to the problem of making exterior grade Plyron, the end uses to which existing grades of Plyron can be put should be clearly stated. For instance, Plyron faced with a standard grade of hardboard and solidly bonded with a phenolic plywood glue passes the 10-cycle test, but face plies are softened. As a result, such Plyron is suitable for all construction uses except where subjected to continuous outside exposure. It is hoped that modifications of phenolic plywood glues, or of the treated hardboards or both, will overcome the problem in the near future and make Plyron available for unlimited use.

Properties Affecting Bond

A number of the physical characteristics of hardboards influence the quality of the bond between hardboards and fir veneer using a phenolic plywood resin.

The most prominent physical characteristic is that produced by treatment of the board with oxidizing oils or phenolic resins. These are the treatments currently used to make the exterior grades of hardboard, and there is a distinct difference in the bonding characteristics of boards due to the method of manufacture.

The presence of oxidizing oils or high surface concentrations of resin almost completely prevents the adhesion of the phenolic glue films to the

Modified Knife Test*			Shear Test		
Dry	Wet	Boil	Dry	Wet	Boil
1-0	7-1	8-2	166-100	144-100	94-100
1-1	9-1	9-2			
3-5	7-7	10-10	225-100	145-100	95-100
6-7	6-9	10-10			
2-2	8-9	9-10	181-100	161-100	100-100
2-8	7-9	9-10			
9-9	10-10	10-10	140-100	111-100	85-100
9-9	10-10	10-10			
4-5	8-5	9-9	127-100	114-100	89-100
6-7	7-5	7-9			
9-3	10-10	10-10	136-100	114-100	85-100
9-10	10-10	10-10			

Panel Construction: 3/16" Fir Cores & Centers
1/10" Hardboard Facer

* Each pair of figures represents the outside glue lines of a separate test sample. To obtain percent wood failure, multiply the figures by ten.

Fig. 1.—Comparison of knife and shear test results on ¾-inch Plyron

[1] Presented at meeting of Hardboard Division, Pacific Northwest Section, FPRS, May 17, 1954, in Aberdeen, Wash.

The Author: Alan L. Lambuth received B. S. degree in chemistry from U. of Washington in 1941. Since graduation he has been research chemist for Monsanto Chemical Co. in field of synthetic resins and adhesives.

surface of the hardboard. Sanding, planing, or wire brushing the hardboard is required in order to obtain a satisfactory bond, and on many boards even these treatments are not adequate.

The condition of the hardboard surface also influences its ease of bonding with phenolic plywood adhesives. The polish on the surface of a board does not of itself interfere with adhesion. It frequently indicates high surface resin content, however, which does make the board harder to glue.

The screen impression on standard grade wet process boards does not seem to prevent good adhesion in spite of the reduced contact area. On treated wet process boards it is detrimental, but, since the treated surface has to be machined before gluing anyway, the screen marks are removed in the process. Latent screen impressions, such as those left after a second pressing, have little effect by comparison.

Surface Effects

The two surfaces of hardboard may differ in bonding characteristics. Wet process boards are generally homogeneous throughout and can be glued equally well on either side if the screen impression is planed off. Since they always have a screen impression, that is the side glued.

With dry process boards, there sometimes appears to be a difference in surface character related to their position in the press at the time of manufacture. One side can be appreciably harder and more difficult to glue with phenolic resin adhesives than the other side of the same board. This difference is often not apparent to the eye but can easily be shown by comparing the amount of fiber pulled from the two sides of the board with scotch cellophane tape. For this sort of identification, the scotch tape test is an invaluable tool. It consists of pressing a strip of tape onto the surface of a hardboard with moderate finger pressure, then pulling it off again with a right angle pull. The side showing less wood fiber on the scotch tape is almost invariably the bottom manufactured side.

Another benefit is derived from identifying and gluing the more fibrous side of a dry process board; namely, the denser side becomes the wear surface of the Plyron. It is felt that a permanent identifying mark on one side of dry process boards is worthwhile for the reasons given.

The normal moisture content of most hardboards is 5 to 8 per cent on a bone-dry basis. This is an ideal range for hot pressing and constitutes no problem. Small losses of moisture during the pressing operation are offset by the amount added with the glue.

Density Effects

The density of a hardboard has little effect on adhesion with phenolic adhesives if the density results only from the use of high pressures during its manufacture. Where high density is the result of high resin content or of a hardening treatment however, it indicates adhesion difficulties.

The thickness of a hardboard influences its bonding properties only through pressing time which, as with wood veneer, must be adjusted to attain the desired temperatures of the glue lines. Most hardboards, because of their higher density, tend to transmit heat more readily than wood.

Figures 2 and 3 show the comparative elapsed times for an inner glue line to reach a given temperature with hardboard and with wood veneer faced panels. This property of hardboard permits somewhat shorter pressing times than corresponding all-wood constructions, but it is felt to be detrimental to phenolic resin adhesives by accentuating over-penetration. The use of a minimum assembly time limit tends to correct this condition.

Finally, the material from which a hardboard is made exerts some influence on ease of gluing with phenolic plywood adhesives, although these differences are overshadowed by other characteristics of the board, such as surface treatment and condition. Fiber boards and particle boards appear to glue equally well, other things being equal, but chip boards sometimes reflect the character of the raw material to a greater degree. A board made with ponderosa pine chips, for instance, is subject to the normal limitations for gluing ponderosa pine veneer.

There are a few special cases of hardboard gluing and handling. Particle overlays, although not commonly used, are glued readily with phenolic plywood adhesives. Overlaying plywood with a treated pulp sheet, while a step removed from hardboard gluing, may be done with normal phenolic resin adhesives.

Comparison of Glues

Bearing in mind the limitations imposed by the hardboard, let us compare phenol formaldehyde resin glues with

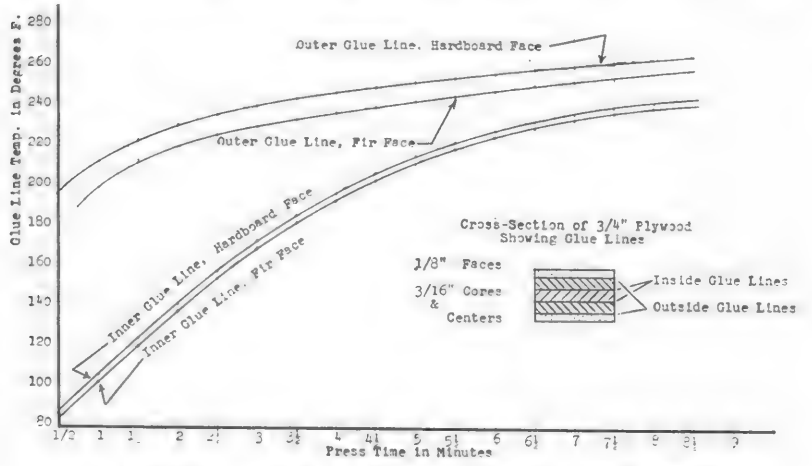


Fig. 2.—Comparison of glue line temperatures—hardboard faced vs. fir faced ¾-inch plywood at 285° F.

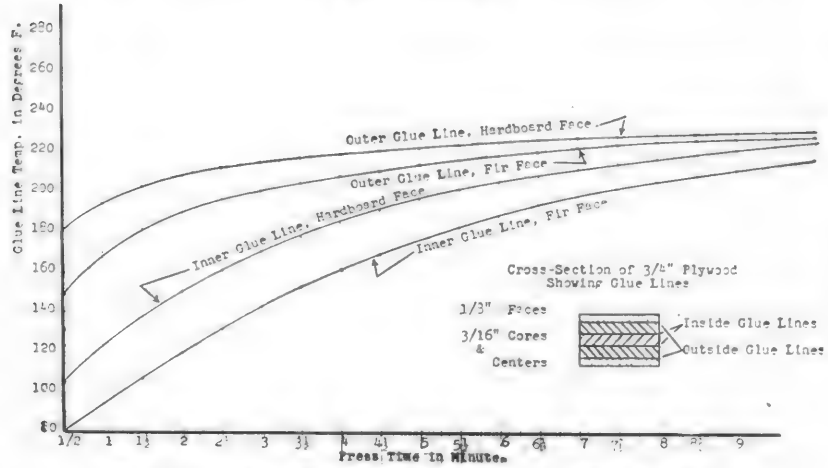


Fig. 3.—Comparison of glue line temperatures—hardboard faced vs. fir faced ¾-inch plywood at 240° F.

other types of adhesives for bonding hardboard to plywood.

Phenolic exterior glues are equivalent in cost per thousand square feet of double glue line to urea resin glues extended to a similar degree with wheat flour. They cost 20 to 50 per cent less than melamine fortified urea resin glues and resorcinol or phenol resorcinol resin glues, depending on the degree of fortification. Phenolic interior glues are generally about 10 to 15 per cent more expensive than soybean-blood blend glues.

The phenolic resin glues are the least expensive plywood adhesives offering a boil-proof bond. Whether this is an essential quality for Plyron has not yet been determined on an end use basis. On a cost basis, glue costs are no greater for hardboard faced panels than for normal plywood because the rates of glue application are the same.

Taken as a group, the phenolic plywood glues are no more difficult or troublesome to prepare than protein adhesives, although most of the phenolics require a longer mixing time.

The production rate with phenolic adhesives, as measured by pressing time, is 25 to 50 per cent slower than with hot press protein glues. Usually this is not an operating problem because the press capacity of most plywood mills is sufficient to keep ahead of the spreader crews even at the slower rate. Where pressing time is a problem, however, combination protein-phenolic resin adhesives are available at about the cost of interior resin glue. These glues have the fast-setting properties of protein adhesives and most of the weatherproof bond characteristics of phenol resin glues after a short cure in the hot stack.

Phenolic plywood adhesives are completely mold resistant. This is also true of protein-phenolic adhesives which, on a proportionate basis, are still substantially resin glues.

Temperature Requirements

All hot press plywood adhesives use the same range of pressures during the pressing cycle, but there are differences in the temperatures required. Protein hot press glues in general call for lower press temperatures which, together with shorter pressing times, result in less permanent compression. The amount is slight, however, usually not over 1/64 inch.

Phenolic plywood glues have better assembly time tolerance than do protein adhesives. Panels may be pressed sooner after spreading or may be held out twice as long without reducing the quality of adhesion, and layup procedures are more flexible as a result. Urea glues have even greater assembly time tolerance, however.

The foregoing discusses factors affecting the adhesion of hardboards to fir plywood with phenolic resin adhesives, and the relative merits of these adhesives compared with other types of plywood glues. The discussion was limited to the use of hardboards in plywood construction because phenol resin adhesives are seldom used at this time to bond hardboards to other constructions, such as lumber cores and flush door frames.

By the combined efforts of hardboard users and adhesive manufacturers, the remaining major problem of improving the adhesion of exterior grade hardboards to fir plywood should be solved in the near future.

Milling Applied to the Modern Distribution Yard[1]

MICHAEL A. SELLNER

Resident Sales & Operations Manager, Weyerhaeuser Sales Co., Baltimore, Md.

Because of its proximity to lumber consuming centers, the distribution yard is well suited to perform a complete milling function. This article describes milling and grinding room equipment, types of millwork produced, and cost factors involved in producing millwork items at a distribution yard.

OUR MAJOR EAST COAST distributing yards are designed to service an area stretching from Maine to the Carolinas and from the East Coast to the Ohio line. Their well balanced, complete West Coast lumber inventories are supplemented by a well-planned milling service. These are well organized and fully equipped units designed to handle large and small orders for millwork of both standard and special types with dispatch.

Service is of the utmost importance. The millwork must be well manufactured as measured by highest West Coast standards and cost must be commensurate with the work performed and in line with standard millwork prices.

Essentially, the mills at each operation are similar. There are minor differences in equipment, however, which are due either to the nature of work at the mill or to the age of the mill.

Since approximately 20 per cent of our sales volume is modified by milling, the mill is a very essential part of our business. It enables our Sales Department to convert standard square-edge stock into a multitude of patterns to fit the needs of the customer on a "right now" basis. Often, when time is of the essence, we land an order because an item can be milled in a matter of a few days, rather than a few weeks or a month or more, as is quite common when the milling is performed by a shipping mill. We also do not frown on special patterns of millwork. In fact, we welcome them, since we grind these knives ourselves.

In addition to performing the millwork, we are often asked to go one step further and partially or completely fabricate an item. This again is an essential part of our service if the customer desires it.

To do all this and produce quality millwork efficiently requires years of know-how. A distributing yard necessarily must build its work force patiently over a period of years, with men of special skills. Where it cannot hire men with proper qualifications, it must train them.

An added service in the distributing yard is that of custom milling, where the customer may have his own lumber milled to standard or special patterns at an economical price. His work is meshed into the daily run of millwork. Milling is scheduled and shipment is effected promptly.

Where necessary it is also possible to make arrangements for storage of the

[1] Presented at a meeting of the Northeast Section, F.P.R.S., Nov. 4–5, 1954, in New York City.

The Author: Michael A. Sellner received his B.S. degree from New York State College of Forestry in 1936. He was associated with the U. S. Forest Service and operated a hardwood mill and lumber business before joining the Weyerhaeuser Co.

Material to be milled is lined up on tracks for each machine, ready to enter the mill.

material for a longer period to suit the requirements of the customer.

Our complete milling service consists of a fully-equipped, separate planing mill and sawmill at each of three major distributing yards.

Because of the increased demand for pressure-treated lumber it is now possible to buy lumber, have it milled to specifications, and treated at two distributing yards. Lumber may be treated with creosote, Wolman Salts, or Minalith—a fire retardant chemical.

Planing Mill Equipment

The planing mill consists of an area of approximately 14,000 sq. ft. completely under cover. The building is of heavy mill construction and may be enclosed during the winter months or inclement weather by means of overhead or sliding doors.

Machines are individually accessible by means of narrow gauge tracks so that work flows to and from each machine to separate storage tracks. Storage of unmilled material on narrow gauge cars is available in front and to the rear of the machine to minimize interruptions.

Feeding material to the machine is done by hand from these loads. This may seem strange, since you would expect that a large organization would be more highly mechanized in this regard. However, because the average order is small and set-ups are frequent, an investment in loaders and unloaders for each machine cannot be justified.

Because the planer-matcher is a highly productive unit, stock is taken away at the outfeed end only by mechanical means, but it is ultimately loaded in units on yard trucks by hand labor. All other machines are unloaded by hand in similar fashion. Full loads are then transported on narrow gauge tracks via gasoline-electric tractors to loading or storage areas for further handling.

The following planing mill equipment is typical of a distributing yard mill: planer-matcher, moulder, band rip saw, band resaw, table cut-off saws, gang rip saw, movable rip plywood saw, multiple boring machine, double-end trimmer, and miscellaneous special equipment.

Planer-Matcher: These are 3600-RPM 20-inch x 8-inch, 8-knife, ball-bearing, motorized units fully equipped. The cutting circle is 9 inches. Including the feed motor, this unit requires 185 h.p. to operate it. It is a six-head machine and is equipped with top and bottom profilers, which makes it a very flexible unit for our work. All top motors are operated individually by motorized hoists for quick set-up changes. Top and bottom profilers are equipped with a unique removable yoke and arbor cartridge unit.

A 7-roll, ball-and-roller-bearing feed table is situated at the infeed end of the machine and can handle stock 24 feet long. At the outfeed end, a motorized grading table takes the stock away from the machine. Side heads are the Philbrick 8-knife generated type.

At one operation this unit is equipped with a "Dyna-Torque" automatic clutch, electronic controls, and feed-speed indicator. Speeds can be controlled in an exacting manner from 65 to 360 feet per minute. With such control it is possible, with the use of pattern knives, to turn out work comparable to that of the finest moulders at much higher speeds.

Moulder: Each operation is equipped with a 4-inch x 12-inch or 5-inch x 12-inch No. 134 BM, 5-head, travelling feed-bed moulder. Side heads are of the tilting type (front head tilts 15° in either direction, while the back head tilts 15° out and 5° in). They are equipped with 6 knives and a 7⅛-inch cutting circle.

Feed ranges from 17 to 168 feet per minute permit running the most intricate mouldings in a satisfactory manner.

Band Ripsaws: Our 4-inch ripsaws are of rather old vintage, but are still capable of doing the work required of them. This consists primarily of ripping wider widths of boards and dimension to narrower widths.

Band Resaws: One operation finds it necessary to have two saws of this type, whereas the other operations each have one. They are equipped with 7-inch bands.

All resaws are equipped with tilting side rolls which enable remanufacture of square-edged stock to bevel siding, in addition to the regular resawing jobs scheduled for these machines. More lumber goes through these units in the course of an average year than through any other single machine in the mills. With their aid we are able to replace our stocks of depleted dimension items when necessary.

Gang Ripsaw: Only one operation is equipped with this piece of equipment. It is used for multiple rip work. In a year's time this machine paid for itself by supplying the crossings necessary for handling ship cargoes through that operation.

Cut-off Saws: Each operation is well equipped with a variety of cut-off saws of a number of popular makes, each having certain advantages. These saws operate at 3400 rpm, which speed results in fine quality cuts on softwoods, particularly with the use of carbide saws.

Our plants are equipped with a large chain-feed timber cut-off saw, used in precise crosscutting of timbers. This saw is equipped with a 10 h.p. motor which operates a 48-inch saw blade with ¼-inch kerf. Dado attachments are also part of the equipment used in connection with this unit.

Plywood Ripsaw: A special piece of equipment found at one operation is a table saw used to rip large sheets of plywood into smaller sheets. This saw is unusual in that the sheet of plywood remains stationary on the table while the saw travels. Foot pedals control the movement of the saw in both directions.

Carbide blades have proved effective in accomplishing the cutting job. The blade in this case is a ⅛-inch x 40-tooth 15° alternate bevel type.

Multiple Boring Machine: Each operation has a multiple boring machine which is particularly useful in our truss department activities. The maximum number of holes which it can bore at one stroke is 12. The largest diameter which it can bore is ½ inch.

Accessory Equipment: The assorted variety of millwork which we produce requires an ingenious assortment of accessory equipment, including cutterheads, splitter saws with raised-edge collars, slitting heads, dado sets in a number of diameters and for cuts of varying widths up to 6 inches, rafter

heads, router bits, grinder room, and saw fitting and tensioning equipment.

With the large list of equipment mentioned, maintenance is a constant and important problem. It requires an intelligent work force to keep the plant operating and keep knives and saws in good repair and proper working order. Also, it requires a certain knowledge of cutting angles and feed speeds to get the required knife marks per inch, as well as a working knowledge of a variety of commercially important wood species and their milling characteristics.

Sawmill Equipment

The large stocks of timber handled by our distributing yards make it necessary for them to have a sizeable sawmill to supplement their milling equipment. Our sawmills, approximately 12,000 sq. ft. in area, are designed to handle timbers of maximum size. The mills are therefore equipped with resaws with 12-inch bands and large timber sizers. These latter units are equipped with round heads and thin knives so that we can do a fine dressing job. Bands are serviced on the job in our completely equipped saw grinding and fitting rooms, where we also do our own welding.

The largest timber that we can handle in both units is a 24-inch x 24-inch x 60-foot.

Crosscutting in our sawmills is accomplished by means of a "jump-saw" operated from below the timber deck by means of an air solenoid.

The mills are almost completely mechanized, hand labor being used only for building up units. Each mill is serviced either by a diesel locomotive crane, an electric overhead crane or a "king-sized" 9-ton lift truck. Chains and live rolls facilitate handling on the timber deck. The resaw and sizer are situated so that they may be used singly or in line.

Although timbers represent only a small portion of our business, they are nevertheless a most important segment of it. Often an order would be lost if we were unable to supply the timbers to go along with the balance of the order.

Cost of Millwork

The cost of milling has been determined by a careful time study carried on over a representative period on a day-to-day and job-to-job basis. All important cost items were considered, charted, and analyzed. Jobs were carefully grouped and averages taken. The ultimate result was a basic time study from which a cost table was derived covering all items, with the exception of those considered to be special millwork items. These basic costs are brought up to date as often as is necessary. Costs are quoted on the special milling items, using the time study as a basis and past experience with millwork of this type as a guide.

Back view of machines showing moulder at left, Stetson-Ross and grading table at right. After milling, material leaves machines at this point and is transported to storage sheds for further handling.

Size of Job

Requests for millwork cover orders from a few pieces up to a million feet or more. Since costs are based on orders of 1500 feet or more, customers are encouraged to keep their orders above this figure. On smaller orders, flat charges are quoted, taking into consideration the high cost of set-up time in relation to the running time of the job. The experience of the mill foreman is used to a good advantage in this instance, as his opinion is always sought and considered in arriving at a proper price for running the item in question. He is a valuable aid in figuring costs of knives for special jobs.

Miscellaneous Millwork

Under this heading are classified all jobs which we are asked to do in addition to regular millwork. In this category are the manufacture of roof trusses, packing cases, floats, skids, barricades, fenders, ship camels, fence posts, bulkhead assemblies, special truck body parts, ramps, and other jobs too numerous to mention.

Quality of Work Required

Our success in the millwork field depends upon our ability to produce quality millwork with a superior finish, regardless of species, grade or moisture content. To perform in this manner it is required that our milling personnel have an excellent knowledge of number of knives required, ideal running speeds, and milling characteristics of our West Coast lumber species, as well as local woods.

Tables of cutting angles and knife cuts per inch supplied by major manufacturers of milling equipment serve as a guide in solving daily milling problems. They are extremely useful in acquainting the men with milling techniques of unfamiliar species.

More fir lumber (75 per cent) goes through our mills than any other single species, with the pines (white and ponderosa) next in line (20 per cent). All other species make up the remaining 5 per cent.

We find that flat grain, dry fir is the most difficult wood to mill of all the West Coast woods. A 25° cutting angle, after jointing, produces a satisfactory milled surface. The heel of the knife must be $\frac{1}{32}$-inch or less for best results. The minimum dressing should be $\frac{1}{32}$-inch on a dressed surface and $\frac{1}{16}$-inch on a resawn surface. Running speeds resulting in 8 to 12 knife cuts per inch should always be the maximum which the number of knives permits, to prevent rapid dulling and burning of the knives.

Species of pine, either white or ponderosa, can be run satisfactorily with a maximum heel of $\frac{1}{16}$-inch. Minimum dressing on uniform stock can be 1/64-inch.

It is difficult to set up any firm rules for desirable running speeds, due to the variation of grain and moisture within the limits of any one species of lumber. The know-how of the machine operator and mill foreman enables them to find the proper solution to any particular problem of this type.

Metropolitan areas consume large quantities of lower grades of clear lumber milled to popular interior trim items. Our milled-to-pattern knives for these standardized patterns enable us to do a superior job on millwork of this type when run on our milling machinery.

From a mill point of view, we can say that modern milling machinery has brought about better utilization of low-grade lumber by improving its appearance. Certainly this is a most important contribution to the forest products industry.

Items of Millwork

In day-to-day relations with our customers we are called upon to mill such items as: standard items of interior and exterior trim, variations and special

items of both, siding, ship decking, center matching, grooved for splines (all thicknesses from 2″ to 8″), rounds, rails, reeded stock, stepping, sills (countless varieties), wall-window stock, fir gutter, boardwalk stock, boardwalk rails, conveyor sides, window trim items, log-cabin siding, flooring, cant strips, wavy-edged siding, scalloped trim, and form stock.

Grinding Room Equipment

To furnish knives which perform the variety of patterns listed requires a well-equipped grinding room with an adequate inventory of knives, cutterheads, and sufficient personnel to prepare the heads in advance for setting-up purposes. Costly set-up time is kept at a minimum.

Generally speaking, knives are set up in their proper heads already jointed on a motorized setting stand as the jobs are required by the mill. A mill foreman and one assistant can keep the planing mill and sawmill equipment in proper working condition. On rare occasions, when the saw operators run into steel or other foreign objects with their blades, this crew may find it difficult to handle this much work. By having extra saw blades on hand, we get through such an emergency with little difficulty.

Grinding equipment for planer knives at all operations is of the hollow-ground or straight-bevel type. Experience leads us to believe that the latter is preferable because it holds its edge longer and is subject to less vibration, which we feel results in a better milling job.

Standard equipment for the grinding room is: knife grinders with built-in lubricating system, motorized setting stand, stationary knife setting stand, knife balancing equipment, cutterheads, pattern knives, straight knife stock in all lengths up to 24 inches, table grinder for small knife grinding, and supply of grinding wheels.

Conclusions

1. Because of its strategic location with respect to lumber consuming centers, the distribution yard is better suited to perform its complete milling function than most decentralized milling units.

2. The size of the investment in modern milling machinery necessary for proper performance (approximately $350,000 in plant and machinery) precludes the possibility of smaller plants fulfilling this function satisfactorily.

3. Centralized facilities of the distribution yard minimize handling and reduce milling costs.

4. The know-how of the distribution yard mill force, combined with the well-equipped mill, produces quality millwork.

5. Service is the end product of the distribution yard mill.

Acknowledgments

The author wishes to express his sincere appreciation to friends and fellow employees for their helpful suggestions in preparing this paper. These include: A. N. Fredrickson, Vice-President & Manager, Eastern Division; Ralph S. Boyd, Assistant to Manager, Eastern Division; William W. Ude, Sales Manager; Joseph Delli Sante, Assistant to Manager; Harry A. Nichols, Mill Foreman, Baltimore Branch; and Ethel Zimmerman, Secretary.

Cost Control in Lumber Manufacturing[1]

FRANK L. MUNCY

Certified Public Accountant; Partner, Rodolph, Muncy, McPherson & Co., San Francisco, Calif.

Operating statements of fictitious lumber manufacturer are given to illustrate cost accounting system. Reports should provide management with accurate unit production costs, show use and waste of materials, reveal productivity of labor, and describe expenses.

IN THE LUMBER INDUSTRY, as in all American industries, the objective is to produce a net profit for the owners. The lumber sales market is notable as a truly "free market", and it is not uncommon to have sizable price fluctuations over relatively short periods of time. Because the free market prevents price control, lumber producers are acutely aware of the necessity for the control of manufacturing costs. This awareness is reflected in the way lumber producers constantly refer to costs on a unit of production basis, the unit being a thousand feet, log scale or board measure, as the case may be.

To arrive at a salable end-product, lumber may pass through a number of manufacturing processes—logging, log hauling, sawmilling, piling, drying, remanufacturing, and shipping. As the product passes through these processes the costs of the final product combine to determine the cost of lumber sold. Thus lumber cost accounting is sometimes referred to as a process cost accounting system.

Cost Accounting

The accountant reports the costs of the various processes to management through a series of operating reports. To be adequate, these reports should contain a maximum amount of information concerning costs and operating data. Operating reports should reflect actual working conditions and situations, facilitate effective supervision of plant operation, assist in the attainment of high standards of operating efficiency. They should also be capable of aiding management in determining financial and operating policies.

If properly prepared and presented, the accountant's reports will provide management with accurate unit production costs, tell the story of the use and waste of materials, reveal the productivity of labor, and adequately describe expenses. The reports should be adaptable to changing situations and methods of production. Equally important, the cost accounting system, and its end product, the reports, must provide this information with a minimum of time and effort on the part of the accountant who prepares them and the executive who reads them.

Sources of Cost Information

To properly prepare reports to management, the cost accountant must first identify costs. Being able to identify costs calls for consistent cooperation from departmental foremen. The accountant should visit all operations to

[1] Presented at a meeting of the Northern California Section, FPRS, April 23, 1954, in San Francisco, Calif.

The Author: Frank L. Muncy holds B.S. degree from the U. of California. He is past president of San Francisco chapter, California Society of Certified Public Accountants and San Francisco chapter, National Assoc. of Cost Accountants.

familiarize himself with the actual flow of the product through the manufacturing processes so that he may present cost figures in terms of what happened in the plant. Such first hand information is often necessary to avoid instances of "the tail wagging the dog", for a cost accounting system should conform to actual operating conditions.

It follows that foremen must be alert to changes which may nullify his reporting of the actual operating conditions. Breakdowns and lost time should be carefully recorded and reported. In return, it is the cost accountant's responsibility to furnish timely cost figures to the foremen, preferably no later than 10 or 15 days after the close of the month.

Example of Cost Accounting

To illustrate the preparation of operating statements, pro-forma statements have been prepared showing the results of operations of the fictitious Western Pine and Fir Lumber Company (a corporation). The company owns 200 million feet of pine timber which cost $15 per M and 200 million feet of fir timber costing $5 per M. The sawmill is capable of producing 100,000 board feet of lumber in an 8 hour shift. Annual production is 40,000,000 board feet, the mill operating 2 shifts for approximately 9 months.

The company cuts about 50 per cent pine and 50 per cent fir, and of this annual cut one-half of the logging is contracted to outsiders at $27 per M feet. The balance of the annual cut is logged by the company.

The company's facilities include logging and hauling equipment, sawmill, dry kilns, planing mill, and a box factory capable of producing 10,000,000 feet of shook.

Control Points

Definite control points which reflect the volume flow of the product should be established. Logs are usually scaled at the time of falling, at the woods log landing where they are loaded on trucks for hauling, at the pond, and at the sawmill deck.

In the example we have assumed log inventories only at the mill pond. Had there been logs at the truck landings, inventories would have been taken off at average cost of $15 per M just before log hauling costs were added (Table 5A). In this respect our example has been purposely simplified to show how reports must be changed to fit operating conditions.

Lumber is usually tallied at the green chain, sometimes at the dry chain, and usually upon transfer to box factory and/or the planing mill, and definitely when it is shipped.

WESTERN PINE & FIR LUMBER CO.
Table 1.—STATEMENT OF INCOME AND EARNINGS RETAINED IN THE BUSINESS, YEAR ENDED DECEMBER 31, 1953

	M Feet	Amount	Average
Pine lumber sales, ADF, com. and discount	20,000	$2,000,000	$100.00
Cost of pine lumber sold		1,499,000	74.95
Profit on pine	20,000	501,000	25.05
Fir lumber sales, ADF, com. and discount	10,000	700,000	70.00
Cost of fir lumber sold		566,010	56.60
Profit on fir	10,000	133,990	13.40
Shook sales, ADF, com. and discount	10,000	900,000	90.00
Cost of shook sold		830,000	83.00
Profit on shook	10,000	70,000	7.00
Total profit on lumber and shook	40,000	704,990	$ 17.63
Other income		20,010	
Total income		725,000	
General and administrative expense (Schedule J)		325,000	
Net income before provision for income tax		400,000	
Provision for Federal and state income taxes		215,000	
Net income for the year		185,000	
Less dividends paid		85,000	
Net income retained in the business		100,000	
Net income of prior years retained at the beginning of the year		600,000	
Earnings retained in the business, end of year		$ 700,000	

Table 2.—COST OF PINE LUMBER SOLD, YEAR ENDED DECEMBER 31, 1953

	Schedule No.	M Feet	Amount	Average
Depletion	--	21,000	$ 315,000	$ 15.00
Contracted logging and hauling	--	10,000	270,000	27.00
Company logging and hauling	A	11,000	275,000	25.00
Logging road costs	B	21,000	105,000	5.00
Total	--	21,000	965,000	45.95
Beginning inventory—logs	--	4,000	180,000	45.00
Total	--	25,000	1,145,000	45.80
Ending inventory—logs	--	3,000	137,400	45.80
Net	--	22,000	1,007,600	45.80
Pond costs	C		33,000	1.50
Pine logs to mill, log scale	--	22,000	1,040,600	47.30
Underrun	--	1,000		
Pine logs to mill, lumber scale		21,000	1,040,600	49.55
Sawmill costs	D		210,000	10.00
Green yard costs	E		42,000	2.00
Cost of pine lumber to pile	--	21,000	1,292,600	61.55
Beginning inventory—lumber	--	9,000	597,400	66.38
Total	--	30,000	1,890,000	63.00
Ending inventory—lumber	--	10,000	630,000	63.00
Pine lumber shipped	--	20,000	1,260,000	63.00
Dry yard costs	F	20,000	60,000	3.00
Dry kiln costs	G	16,000	64,000	4.00
Planing mill costs	H	15,000	75,000	5.00
Shipping costs	I	20,000	40,000	2.00
Cost of pine lumber sold	--	20,000	$1,499,000	$ 74.95

Table 3.—COST OF FIR LUMBER SOLD, YEAR ENDED DECEMBER 31, 1953

	Schedule No.	M Feet	Amount	Average
Depletion	--	16,000	$ 80,000	$ 5.00
Contracted logging and hauling		10,000	270,000	27.00
Company logging and hauling	A	6,000	150,000	25.00
Logging road costs	B	16,000	80,000	5.00
Total	--	16,000	580,000	36.25
Beginning inventory—logs	--	6,000	210,000	35.00
Total	--	22,000	790,000	35.90
Ending inventory—logs	--	5,000	179,500	35.90
Net	--	17,000	610,500	35.90
Pond costs	C		25,500	1.50
Fir logs to mill, log scale	--	17,000	636,000	37.40
Overrun	--	2,000		
Fir logs to mill, lumber sale	--	19,000	636,000	33.47
Sawmill costs	D		190,000	10.00
Green yard costs	E		38,000	2.00
Cost of fir lumber to pile	--	19,000	864,000	45.47
Beginning inventory—lumber	--	7,000	332,010	47.43
Total	--	26,000	1,196,010	46.00
Ending inventory—lumber	--	4,000	184,000	46.00
Lumber shipped or transferred	--	22,000	1,012,010	46.00
Dry yard costs	F		66,000	3.00
Total	--	22,000	1,078,010	49.00

(Continued on page 184)

(Table 3.—Continued from page 183)

Lumber transferred to box factory	--	12,000	588,000	49.00
Fir lumber shipped	--	10,000	490,010	49.00
Dry kiln costs	G	4,000	16,000	4.00
Planing mill costs	H	8,000	40,000	5.00
Shipping costs	I	10,000	20,000	2.00
Cost of fir lumber sold	--	10,000	$ 566,010	$ 56.60

Table 4.—COST OF SHOOK SOLD, YEAR ENDED DECEMBER 31, 1953

	M Feet	Amount	Average
Transfers to factory	12,000	$ 588,000	$ 49.00
Surfacing costs (Schedule H)	------	60,000	5.00
	12,000	648,000	54.00
Waste 16.7%	2,000	----------	-------
Lumber to factory, shook footage	10,000	648,000	64.80
Manufacturing costs:			
Labor	10,000	110,000	11.00
P. R. taxes and insurance	------	7,500	.75
Supplies and expense	------	12,000	1.20
Maintenance and repairs	------	8,000	.80
Power	------	7,000	.70
Wire, rope and nails	------	8,000	.80
Nailing expense	------	7,500	.75
Total manufacturing costs	10,000	160,000	16.00
Cost of shook produced	10,000	808,000	80.80
Beginning inventory	500	42,500	85.00
Total	10,500	850,500	81.00
Ending inventory	500	40,500	81.00
Net	10,000	810,000	81.00
Shipping costs (Schedule I)	------	20,000	2.00
Cost of shook sold	10,000	$ 830,000	$ 83.00

Table 5A.—MANUFACTURING COSTS, YEAR 1953

Schedule A—Company Logging and Hauling:	M Feet	Amount	Average
Woods operating costs:			
Labor—falling and bucking	17,000	$ 72,250	$ 4.25
—yarding and loading	------	29,750	1.75
—supervision, timekeeping and scaling	------	12,750	.75
—repair shop	------	21,250	1.25
Payroll taxes and insurance	------	11,900	.70
Wire rope	------	6,800	.40
Gas, oil and grease	------	25,500	1.50
Other operating supplies and expenses	------	19,550	1.15
Equipment rental	------	17,000	1.00
Woods boarding house operation	------	21,250	1.25
General expense	------	17,000	1.00
Subtotal—operating costs	17,000	255,000	15.00
Log hauling costs:			
Trucking labor	17,000	37,400	2.20
Payroll taxes and insurance	------	3,060	.18
Gas, oil and grease	------	19,550	1.15
Tires and tubes	------	25,500	1.50
Maintenance and repairs	------	53,040	3.12
Supplies and expense	------	31,450	1.85
Subtotal—hauling costs	17,000	170,000	10.00
Total logging and hauling costs	17,000	$ 425,000	$ 25.00
Pine logs	11,000	$ 275,000	$ 25.00
Fir logs	6,000	150,000	25.00
Total	17,000	$ 425,000	$ 25.00

Table 5B.—MANUFACTURING COSTS, YEAR 1953

Schedule B—Logging Road Costs:	M Feet	Amount	Average
Labor—road maintenance	37,000	$ 46,250	$ 1.25
—spur line construction	------	37,000	1.00
Payroll taxes and insurance	------	7,400	.20
Road maintenance supplies and expense	------	27,750	.75
Amortization of main woods road	------	66,600	1.80
Total road costs	37,000	$ 185,000	$ 5.00
Pine logs	21,000	$ 105,000	$ 5.00
Fir logs	16,000	80,000	5.00
Total	37,000	$ 185,000	$ 5.00

Table 5C.—MANUFACTURING COSTS, YEAR 1953

Schedule C—Pond Costs:	M Feet	Amount	Average
Labor	39,000	$ 46,800	$ 1.20
Payroll taxes and insurance	------	1,950	.05
Supplies and expense	------	9,750	.25
Total	39,000	58,500	$ 1.50
Pine logs	22,000	$ 33,000	$ 1.50
Fir logs	17,000	25,500	1.50
Total	39,000	$ 58,500	$ 1.50

The principal checking points are the pond scale (logs dumped into the pond), deck scale (sawmill scale of logs), green chain scale (lumber load tallies to green pile or to dry kiln stocks), and shipping tallies.

By faithfully recording such scales and tallies, the cost of the flow of the product can be satisfactorily described in average costs per M feet and thus provide a periodic cost figure for comparative purposes. This disclosure can be made for the particular month and for year to date, all of which is supported by cumulative daily figures.

Importance of Accurate Inventories

Inventories of logs and lumber play an important part in the determination of average costs. Logs in cold deck should be "estimated" as well as logs in pond. Any experienced logger or lumberman will admit to the lack of accuracy of log deck tallies. However, consistent application of estimation procedures should, over a long period, establish a method of log inventory control.

Monthly inventories create an overall condition to verify effectiveness of checking points. Inventory errors show up in overrun or underrun, and if an abnormal amount of variance occurs, doubt is cast immediately either upon the inventory count or upon scaling practices.

If the control points along the route check out, the overrun or underrun developed may not be a reality, but a traceable error in some particular tally or scale. For example, green chain tallies may consistently support the scaling practice at the sawing deck, but nevertheless, footage is disappearing between the green chain and the shipping dock. Some reasons for such disappearances might be breakage, lumber for plant use not tallied out, inaccurate load estimates of transfers to box factory or planing mill, or inconsistent inventorying of boneyard items.

Determining Inventory Values

In our example we have used the average cost method of determining inventory values. Because of its simplicity it is the most widely used method, although perhaps not the most accurate. The average cost method will show a true picture only if beginning and ending inventories contain the same ratio of the various grades of logs and lumber; however, over the long term the differences caused by this method are negligible.

Other methods used in valuing lumber are: (1) selling price, less provision for profit, selling and administrative expenses, warehousing, shipping, etc., and (2) cost allocated to grades in the relationship of total cost of pro-

duction to total selling price. This last method gives an accurate inventory result, but the elaborate accounting system required to determine the value makes it undesirable in most cases.

In the example depreciation is included in general and administrative expenses (Table 5J), thus eliminating depreciation from inventory values. The result is a conservative inventory valuation, but more important, the cost statements reflect only controllable costs. The Treasury Department has not given formal approval to eliminating depreciation from inventory values. However, no serious distortion of annual income occurs if the production volumes from year to year are relatively constant.

Cost Reduction

The basic step in cost reduction program is an analysis of all expenditures against which cost reduction efforts will be directed. The analysis could be company-wide to include sales, administrative, and research departments, as well as manufacturing costs. Herein we shall deal only with manufacturing costs.

Supplementary payroll data can yield costs by department showing:

1. Footage handled
2. Average number of workers per day
3. Total hours worked
4. Total wages in dollars
5. Average wage per hour
6. Feet per man hour (production)

The foregoing data presented monthly gives a running comparison with prior periods and establishes a basis of control by management. The current results may not be the goal of low costs envisioned by management but the study of their results does provide a long stride in that direction.

Supplies and expenses for operating the department can be analyzed and likewise controlled.

Repairs and maintenance (including those during the shut down periods) can be analyzed and scrutinized for any departure from essential expenditures in that classification. It is possible that a new machine is in order rather than so much cost for repair and maintenance.

Statistical Data—Sawmill

A monthly summary, compiled from daily reports could present:

1. Number of logs to sawmill (listed by days)
2. Deck scale, total feet (listed by days)
3. Lost time, in minutes (listed by days)
4. Average feet per log
5. Total hours operated
   a) Day shift
   b) Night shift
6. Production in average feet per hour
7. Deck scale by species
   a) Pine
   b) Fir
   c) Other

A review at any given day will pinpoint a departure from accepted performance and enable the management to take timely action with the foreman. Since the figures come from his department, he should already have the answers.

Similar but less extensive controls can be established for the planing mill, moulding mill, and box factory. The latter two especially will be subject to scrutiny for cost due to waste. Any abnormal variation in waste percentages

Table 5D.—MANUFACTURING COSTS, YEAR 1953

Schedule D—Sawmill Costs:	M Feet	Amount	Average
Labor—sawing	40,000	$ 170,000	$ 4.25
—green chain		64,000	1.60
—maintenance		40,000	1.00
—supervision		20,000	.50
Payroll taxes and insurance		14,000	.35
Power		50,000	1.25
Supplies and expense—Operating		22,000	.55
—Maintenance		20,000	.50
Total	40,000	$ 400,000	$ 10.00
Pine lumber	21,000	$ 210,000	$ 10.00
Fir lumber	19,000	190,000	10.00
Total	40,000	$ 400,000	$ 10.00

Table 5E.—MANUFACTURING COSTS, YEAR 1953

Schedule E—Green Yard Costs:	M Feet	Amount	Average
Labor—Hauling	40,000	$ 30,000	$ .75
—Piling		24,000	.60
—Maintenance		4,000	.10
—Supervision		6,000	.15
Payroll taxes and insurance		2,800	.07
Supplies and expense—Operating		5,200	.13
—Maintenance		8,000	.20
Total	40,000	$ 80,000	$ 2.00
Pine lumber	21,000	$ 42,000	$ 2.00
Fir lumber	19,000	38,000	2.00
Total	40,000	$ 80,000	$ 2.00

Table 5F.—MANUFACTURING COSTS, YEAR 1953

Schedule F—Dry Yard Costs:	M Feet	Amount	Average
Labor—Hauling	42,000	$ 37,800	$ .90
—Handling		46,200	1.10
—Maintenance		16,800	.40
—Supervision		6,300	.15
Payroll taxes and insurance		3,360	.08
Supplies and expense—Operating		7,140	.17
—Maintenance		8,400	.20
Total	42,000	$ 126,000	$ 3.00
Pine lumber	20,000	$ 60,000	$ 3.00
Fir lumber	22,000	66,000	3.00
Total	42,000	$ 126,000	$ 3.00

Table 5G.—MANUFACTURING COSTS, YEAR 1953

Schedule G—Dry Kiln Costs:	M Feet	Amount	Average
Labor—Operating	20,000	$ 25,000	$ 1.25
—Maintenance		5,000	.25
Payroll taxes and insurance		1,000	.05
Power		40,000	2.00
Supplies and expense—Operating		5,000	.25
—Maintenance		4,000	.20
Total	20,000	$ 80,000	$ 4.00
Pine lumber	16,000	$ 64,000	$ 4.00
Fir lumber	4,000	16,000	4.00
Total	20,000	$ 80,000	$ 4.00

Table 5H.—MANUFACTURING COSTS, YEAR 1953

Schedule H—Planing Mill Costs:	M Feet	Amount	Average
Labor—Planing	35,000	$ 85,750	$ 2.45
—Chain		38,500	1.10
—Maintenance		5,250	.15
—Supervision		5,250	.15
Payroll taxes and insurance		5,250	.15
Power		21,000	.60
Supplies and expense—Operating		8,750	.25
—Maintenance		5,250	.15
Total	35,000	$ 175,000	$ 5.00
Pine lumber	15,000	$ 75,000	$ 5.00
Fir lumber	8,000	40,000	5.00
Factory lumber	12,000	60,000	5.00
Total	35,000	$ 175,000	$ 5.00

Table 5I.—MANUFACTURING COSTS, YEAR 1953

Schedule I—Shipping Costs:	M Feet	Amount	Average
Labor—Hauling	40,000	$ 20,000	$ .50
—Loading		40,000	1.00
—Maintenance		4,000	.10
—Supervision		4,000	.10
Payroll taxes and insurance		4,000	.10
Supplies and expense—Operating		6,000	.15
—Maintenance		2,000	.05
Total	40,000	$ 80,000	$ 2.00
Pine lumber	20,000	$ 40,000	$ 2.00
Fir lumber	10,000	20,000	2.00
Shook	10,000	20,000	2.00
Total	40,000	$ 80,000	$ 2.00

Table 5J.—MANUFACTURING COSTS, YEAR 1953

Schedule J—General and Administrative Expenses:	
Executive salaries	$ 30,000
Office salaries	30,000
Payroll taxes and insurance	1,000
Travel	4,000
Dues and subscriptions	8,000
Telephone, telegraph and teletype	6,000
Office supplies and expense	3,000
General taxes (other than income)	40,000
Fire and liability insurance	35,000
Use and occupancy insurance	4,000
Interest	3,000
Legal and accounting	10,000
Depreciation	150,000
Miscellaneous expense	1,000
Total	$325,000

will call for immediate explanations and action.

Conclusions

1. Costs are identifiable.

2. Some costs are controllable only by top management (stumpage, wage rated and fringe benefits).

3. Some costs are most effectively controlled by foremen (time spent on repairs and maintenance, material used, spoilage, mismanufacture, sweepers, helpers, oilers, and other items of indirect cost). Therefore, the foreman is a valuable employee in cost control and his interest and efforts must be directed along these lines to bring his influence into maximum use for the total efficiency and cost control.

4. Cost reports must be timely, pointed, and accurate.

5. Cost reports, cost analyses and related studies are an effective tool of the accountant and enable him to serve industry which in turn serves well our economic society.

Sawing Wood with Circular Headsaws[1]

G. W. ANDREWS

Ottawa Laboratory, Forest Products Laboratories of Canada, Division of the Forestry Branch, Department of Northern Affairs and National Resources

Reports on studies of variables inherent in sawing wood, with objective of reducing wood waste volume and increasing lumber recovery. Tests were made of effects of specific gravity of wood, depth of cut, bite, tooth width, and tooth sharpness on power requirements.

WASTE REDUCTION AND UTILIZATION of wood substance unused in sawmilling conversion have been problems of long standing. In the field of sawmill waste utilization, encouraging progress has been recorded in recent years. An increasing volume of this wood substance is now being turned to pulp chips or used in the manufacture of binder board.

Little has so far been accomplished towards the reduction of waste through the improvement of sawmilling methods and practices. This appears to be largely because of the absence of fundamental data essential to the appraisal of the production problems and the development of improved equipment and techniques.

A research sawmill was installed by the Ottawa Laboratory of the Forest Products Laboratories of Canada to permit controlled investigation, in an operational-size mill, of the many factors which affect lumber recovery. Installation of this mill followed a series of studies, carried out from 1947 to 1950, at 60 sawmills in Eastern Canada. Results of these studies were published as Bulletin 99, "Factors Influencing the Manufacture of Sawlogs into Lumber in Eastern Canada", as well as in a number of articles dealing with specific phases of the investigations. It was shown that only 50 per cent of the volume of the average sawlog was manufactured into lumber by sawmills in Eastern Canada; the remainder was converted to various forms of sawmill waste: slabs, edgings, trim, and sawdust.

The primary objectives of the research sawmill are investigation and study of the many variables inherent to the sawing of wood so as to obtain background data. It is hoped that knowledge gained will bring about changes which will result in a reduction in wood waste volume and higher lumber recovery. To enable the effective carrying out of necessary studies, the research sawmill was equipped as a research tool with necessary control and recording devices.

The Research Sawmill

Machinery: Of the 7,000 sawmills in Canada, over 6,000 are of the circular headrig type. It was decided that initially the research work should be on the circular headrig type of mill, because any findings would be generally applicable to circular mills in Canada.

Research in other countries has been mainly on a laboratory scale, although tests at the U. S. Forest Products Laboratory simulated full-scale operation conditions. It was decided that the research sawmill of the Ottawa Laboratory should be a full-scale operation-size mill, so that the work to be undertaken would provide data directly applicable to actual operating conditions.

Machinery similar to that of a conventional circular sawmill was installed during the summer and fall of 1951. Considerable additional equipment was also included in the design and installation, such as a motor generating set for powering the D.C. electric motors on the headsaw and on the carriage drive, as well as elaborate instrumentation.

[1] Presented at a meeting of the Eastern Canadian Section, FPRS, March 14-16, 1955, in Ottawa, Ontario.

The Author: G. W. Andrews holds B.Sc. from U. of New Brunswick, M.Sc. from U. of Toronto. He has been engineer in charge of sawmilling unit at Ottawa Laboratory, Forest Products Laboratories of Canada, since 1952.

Thus, the mill is equipped to permit high flexibility in research work.

The machinery includes a circular headsaw, a 16 foot-5 bunk carriage, an edger, and a trim saw. The motor generating set has a generator output of 75 kw. and permits wide variation in saw and carriage feed speeds. It provides power for the 75 h.p. D.C. motor driving the headsaw and for the 30 h.p. D.C. motor driving the carriage. Saw speeds of 300 to 1,500 r.p.m. and carriage speeds of 30 to 330 ft./min. are possible.

Instrumentation

Instrumentation of the research sawmill is such that it is possible to measure and record simultaneously, for any position of the saw during the cut and for the cut as a whole, saw speed, carriage speed, torque on the headsaw shaft, and the horizontal and vertical forces exerted on the saw. Recording of these variables is by two oscillographs through three analyzers on two graduated paper tapes.

Oscillographs: Two brush oscillographs are used. Each is equipped with two recording pens and two event-marker pens, to record the variables on the tape. The chart paper is 3-15/32 inches wide with longitudinal lines spaced 1 mm. apart and transverse lines spaced 5 mm. apart. Three chart speeds may be used—5, 25, and 125 mm./sec. The oscillographs are operated through three universal analyzers.

Saw Speed: Speed of the saw is measured by means of a micro-switch actuated by a 70° cam mounted on the headsaw shaft. Each revolution of the saw is recorded on one of the oscillograph tapes. The tape moves at one of three predetermined speeds. By determining the relationship between the speed of the tapes and the distance between the saw revolutions as marked on the tape, the r.p.m. of the saw can be calculated.

Carriage Speed: A system of cams attached to a bar at the rear of the carriage actuates a micro-switch as the carriage moves past the saw and a record is made on the tapes of both oscillographs. The bar is equipped with 15 cams, spaced at one foot intervals, and as each cam in turn actuates the micro-switch, the event is recorded on both tapes. Carriage speed is recorded on both tapes to afford a method of synchronizing the two tapes.

The relationship between the speed of the tape and the distance between the recorded "blips", is the basis for determining carriage speed. Carriage speed during each foot of travel, as well as average speed for the cut, can be determined.

Both the saw speed and carriage speed are also shown on dials mounted in the control panel. The speeds are measured by tachometers attached to the headsaw shaft and to the cable drive of the carriage. Both saw and carriage speed can be easily changed or adjusted by rheostats, also mounted on the control panel. The rheostats and dials are used for rough settings but, for test work, actual speeds determined from the tapes are used.

Torque: Torque on the headsaw shaft is picked up by a Baldwin SR4 torquemeter. A flexible coupling and clutch mechanism is installed in the shaft to protect the torquemeter. This mechanism can be set to fail at any desired capacity. Changes in torque are recorded on the tape of one of the oscillographs as a deflection from a zero line. Torque at any moment during the cut, or the average torque for the entire cut can thus be determined.

Horizontal and Vertical Force: Horizontal and vertical force on the saw is picked up initially by two strain gauge pick-ups mounted on the headsaw shaft in a specially designed bearing. These pick-ups are placed between the outer race of the bearing and the housing so that any force on them may be measured and recorded on the oscillograph tapes. Considerable difficulty was encountered in designing proper pick-ups. Four types were built and tried before a satisfactory design was found.

The final set is ring-type, with strain gauges placed inside and out on two sides of the ring, i.e., four gauges on each ring. The ring is bolted directly to the housing on one end and anchored securely inside the outer race of the bearing on the other end. Because gauges are mounted on each side of the ring, compensation is made for rocking. Forces picked up by these units are recorded on the oscillograph tapes as a deflection from a zero line.

Summary of Basic Tests

1. Effect of Specific Gravity of Wood on Headsaw Power Requirements: The mechanical and physical properties of wood depend to a large extent upon its specific gravity. Experiments on a laboratory scale have shown that there is reason to believe that the relationship between cutting forces and specific gravity is positive and linear. It was therefore decided that this relationship should be established for Canadian species under actual operating conditions.

The study was based upon a sample of 1,000 saw-cuts in white pine, white birch, yellow birch, and sugar maple. Observations were obtained for the cutting torque and horizontal and vertical force. For ease in interpretation, horsepower values were calculated from the torque values and are shown in graphic form. Horizontal and vertical force values were expressed in terms of a resultant force and were also expressed graphically. The relationships established are shown in Figures 1 and 2.

It may be seen that power and resultant force increase proportionately through the low density woods such as spruce and pine to a maximum for the high density woods such as oak and maple.

2. Effect of Depth of Cut on Headsaw Power Requirements: Log diameter is one of the many variables affecting power requirements and saw action. In many mills the headsaw r.p.m. is reduced considerably when thick cuts are being made. This reduction in speed can cause inaccuracies in lumber thickness.

To investigate the effect of this variable, a test was carried out on a number

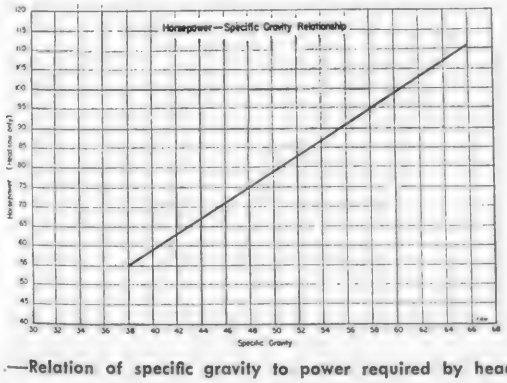


Fig. 1.—Relation of specific gravity to power required by headsaw.

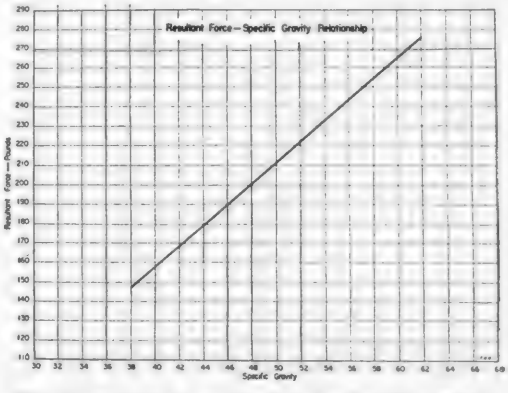


Fig. 2.—Relation of resultant force to specific gravity.

of white pine cants which had been previously prepared to give different depths of cut. One of these cants is shown in Figure 3.

As expected, the power required at the headsaw increased rapidly as the depth of cut increased. In Figure 4 it may be seen that for a 4 in. depth of cut in white pine, approximately 20 h.p. was required, whereas for a 12 in. depth of cut about 70 h.p. was needed. These values would, of course, increase if the species was birch or maple, for example.

Fig. 3.—"Window-stick" cant with four depths of cut.

3. Effect of Bite on Headsaw Power Requirements: The amount of wood removed by each tooth as the saw revolves through the log (bite) can be controlled by varying the carriage speed, the number of teeth on the saw, or the speed at which the saw rotates.

In the average small sawmill in Eastern Canada, control is generally obtained through the sawyer varying the carriage speed depending upon the depth of cut and species being sawn. However, the degree in which he can vary the bite is limited by the feed mechanism which in turn is dependent upon the power available and the saw characteristics.

Generally, in Eastern Canada, fairly fast feed rates and saw speeds are employed so that the average bite is in the order of .08″ per tooth.

It was found that as a result of varying carriage or feed speed and, consequently, the bite, there was a proportionate change in horsepower and that the rate of increase was much more rapid at higher saw speeds (Figure 5).

Although there is a considerable increase in power requirements with increasing bite, economies can be obtained, if sufficient power is available, by operating at a greater bite. For example, considering the 700 r.p.m. curve in Figure 5, it may be seen that doubling the bite from .05 to .10, for example, does not double the horsepower required. Feed speed can be doubled with about an additional 75 per cent horsepower. Within the limits of the gullet capacity and the quality of the finish required, it would appear that many mills could benefit by increasing carriage speed.

4. Effect of Tooth Width on Power Requirements: There is a considerable variation in the width of saw teeth used in small mills. For example, where mills are using a 48″ inserted tooth 7–8 gauge circular saw, the width of teeth varies from 8/32″ to 10/32″. When the wider teeth are in use, a large and unnecessary amount of wood is being lost in the form of sawdust. Because of the greater kerf volume, power requirements are increased.

Two factors must be considered when investigating the effects of tooth width. First, the tooth must be wide enough to give a sufficient clearance between the wood and the saw plate to prevent heating and, consequently, inaccurate sawing. Second, the teeth must not be so narrow that the correspondingly shorter life (because fewer sharpenings can be made) will lead to an exorbitantly high tooth replacement.

Four widths of tooth were used in the test: 7/32, 8/32, 9/32, and 10/32″. Logs of four species were sawn: white pine, white spruce, yellow birch, and sugar maple. Attempts to saw with teeth 7/32″ in width were singularly unsuccessful because of insufficient clearance between the edge of the tooth and the saw plate. The saw became so overheated that during one cut it ran into the cant so badly as to necessitate re-tensioning. These teeth were discarded as impractical for use with the gauge of saw (7–8) being used.

Power requirements were obtained for the remaining tooth widths and the relationship obtained is shown by the curved regression lines in Figure 6. Considering the data for maple, for example, it can be seen that there is an increase of about 20 h.p. or 23 per cent when changing from 8/32″ to 10/32″ teeth.

Although teeth 8/32″ wide were found to be the most efficient, it may perhaps be argued that because of their shorter life, their replacement cost will more than offset any gain in lumber volume obtained.

Considering this second factor, i.e., tooth life, it is estimated that a decrease in width from 9/32″ to 8/32″ will shorten the life of teeth by 50 per cent on the basis of a critical width of 7/32″. Since 9/32″ teeth are those most commonly used in industry, a reduction in width by 1/32″ would mean that because the teeth must be replaced twice as often, the cost of the teeth (which form part of the direct costs of lumber) would be increased approximately 50 per cent. However, it can be shown that this additional cost is more than offset by the increase in lumber production resulting from using teeth 8/32″ wide.

It is generally expected that a set of 9/32″ teeth will saw approximately 40 M ft.b.m. of lumber before being discarded. For a 38 tooth saw and with bits worth 11¢ each, this means that

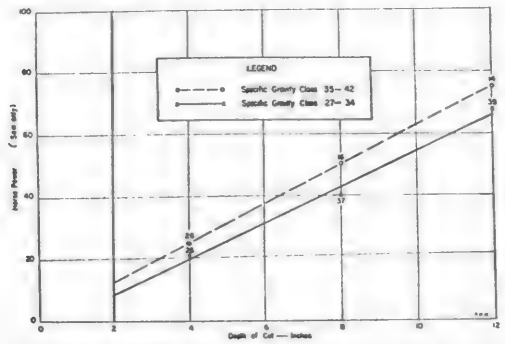


Fig. 4.—Relation of depth of cut to power required by the headsaw.

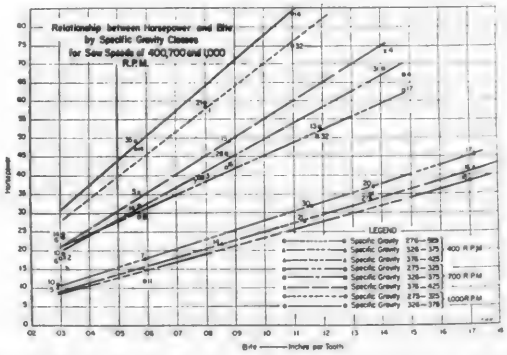

Relationship between Horsepower and Bite by Specific Gravity Classes for Saw Speeds of 400, 700 and 1,000 R.P.M.
LEGEND
Bite — Inches per Tooth

Fig. 5.—Relation of bite of teeth to power required by headsaw.

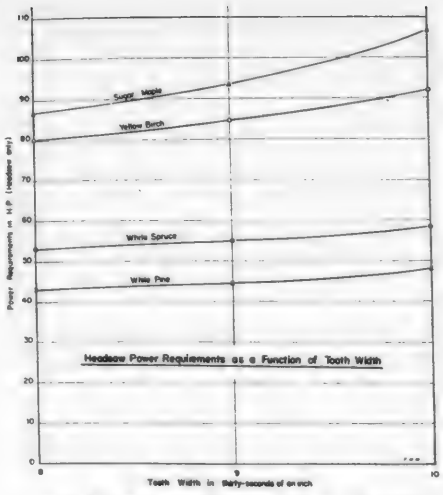


Fig. 6.—Relation of tooth width to power required by headsaw.

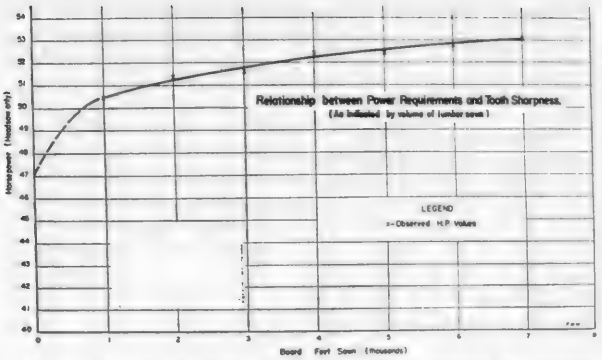


Fig. 7.—Relation of tooth sharpness to power required by headsaw. 7,000 ft. b. m. of lumber were sawed in a continuous run after new bits had been inserted in a circular headsaw. Power requirements increased continuously with decreasing tooth sharpness as the run progressed.

the cost per M would be 4.18/40M × 1000 = 10¢. A reduction in width to 8/32″ would, therefore, mean that the cost of teeth per M would be doubled, i.e., 20¢.

A reduction in tooth width of 1/32″ (8/32″ bits as compared to 9/32″ bits) would in turn reduce the volume of sawdust by 1/9 or 11 per cent. Since 16 per cent of the log volume is normally converted to sawdust,[2] a reduction of 11 per cent, would be equivalent to an additional 2 per cent recovery as lumber. On a 1 M ft.b.m. basis, this would amount to 20 ft.b.m. Assuming an average mill run value of $50 per M, this would mean an additional value of $1. Thus, the saving which would result from a reduction of tooth width to 8/32″ would be 90¢ per M ft.b.m.

In summary, on the basis of both tooth width and tooth life, a tooth width of 8/32″ proved to be the most efficient of those tested. Satisfactory operation is possible with lower power requirements and the increase in the cost for teeth is more than offset by an increase in lumber recovery.

5. Effect of Tooth Sharpness on Sawing: The dulling of saw teeth depends upon the type of steel from which they are made, the species being sawn, the condition of the logs (watered or unwatered), and the amount of wood removed by each tooth. When a small amount of wood is removed, the teeth appear to abrade rather than sever the wood and, following the loss of the initial or factory-sharp edge, the dulling process is accelerated.

For purposes of the test, a new set of standard saw bits (9/32″) was used in a 48″ inserted tooth circular saw. A saw and carriage speed of 700 r.p.m. and 164 ft. per min. was adopted, which provided for a satisfactory tooth penetration of .074″.

The white pine logs used in the test were sawn under adverse conditions in that having been skidded to the log deck they contained a fairly large amount of abrasive material. However, as this is common practice in many small mills, it was felt to be justified.

Some 7,000 ft.b.m. of lumber were sawn during the test. Power requirements were obtained at the beginning of the test and after the sawing of each M ft.b.m. on previously prepared test pieces. Figure 7 summarizes the data obtained. It shows that there is an initial increase of power during the sawing of the first M ft.b.m. of lumber, which reflects the deterioration of the factory sharp edge of the teeth. As the sawing progressed there was a flattening out of the power curve, indicating that although power increased, the dulling of the teeth was a comparatively slow process.

Forty-seven horsepower was required to saw a 10-inch test piece at the start of the test, compared to 53.1 h.p. after the teeth had been used to saw 7 M ft.b.m. This represents an increase of 13 per cent.

Slight heating of the saw occurred after 4 M ft.b.m. of lumber had been sawn but was not sufficient to affect the sawing quality. However, after about 5,500 ft.b.m. had been sawn, the lumber had a decidedly furry aspect, which possibly was the result of the somewhat rounded corners of the teeth and their consequent tearing rather than cutting of the fibres.

During the sawing of the last M ft.b.m., a small amount of "rim wobble" became noticeable with its resultant effect upon the lumber.

It is not possible to state exactly when the teeth should be filed as it depends on a combination of factors whose effects can best be judged by the sawyer. However, for white pine sawn under more or less adverse conditions, filing should take place at about the 4 M ft.b.m. mark.

6. Power Requirements and Efficient Use of Power at the Headsaw: Two of the more common reasons for inaccuracies in lumber and to a certain extent for lower than optimum production are inadequate power and inefficient use of available power.

It is not uncommon for a saw to markedly decrease its speed and laboriously make its way through a log. Since saws are tensioned to operate at a predetermined speed, a slowing down from this speed will lead, if carried far enough, to overheating and rim flutter. This will cause inaccuracies in the lumber, and either a down grading of the lumber or an excessive amount of work for the planing mill.

Slowing down of the saw indicates a lack of power and the only recourse the sawyer has is to decrease the rate of feed. However, this decreases the rate of production and can, through the fibres being abraded rather than sawn, lead to a more rapid dulling of saw teeth.

Because of these undesirable features, investigations were undertaken to determine the amount of power required to saw Canadian species and the combinations of saw and feed speeds which provide the most efficient use of this power.

Results

A. Amount of Power Required to Saw Various Commercial Canadian Species: The first tests were based on saw and carriage speeds commonly used in the smaller mills (saw speed 700 r.p.m.; carriage speed 170 ft./min.). Power requirements under these conditions are shown in Table 1 for the four species tested and for various depths of cut.

Since the power requirements of the headsaw for the species tested were found to depend almost entirely (for similar depths of cut and for similar

[2] ...ell, G. E. Factors influencing the manu... of sawlogs into lumber in Eastern ...da. Bulletin 99, Forest Products Labora... of Canada, 1951.

Table 1.—AVERAGE POWER REQUIREMENTS AT THE HEADSAW FOR SPECIES TESTED. CARRIAGE SPEED, 170 FT./MIN.; SAW SPEED 700 R.P.M.

Species	Depth of Cut, Inches 2	4	6	8	10	12	14
	Horsepower						
White pine	10	20	29	39	49	59	68
White birch	14	29	44	59	73	88	102
Yellow birch	16	33	48	65	79	95	111
Sugar maple	18	37	54	71	89	106	123

Table 2.—AVERAGE POWER REQUIREMENTS AT THE HEADSAW FOR SOME CANADIAN SPECIES. CARRIAGE SPEED, 170 FT./MIN.; SAW SPEED 700 R.P.M.

Species	Depth of Cut, Inches 2	4	6	8	10	12	14
	Horsepower						
Balsam fir) Spruce)	9	17	26	34	43	50	57
Basswood) White pine) Eastern hemlock) Red pine)	10	20	29	39	49	59	68
Western hemlock) Jack pine)	11	22	34	45	55	67	79
Douglas fir	13	26	37	50	62	74	87
Tamarack	13	27	40	54	67	80	94
White birch) Cherry) White elm)	14	29	44	59	73	88	102
Black walnut) Yellow birch)	16	33	48	65	79	95	111
Beech Sugar Maple)	18	37	54	71	89	106	123
Rock elm) White oak)	20	39	59	78	98	117	137

headsaw characteristics) on the specific gravity of wood, most of the common commercial Canadian species were grouped by specific gravity classes and power requirements were determined by simple interpolation. These are indicated in Table 2.

The values shown in Table 2 indicate headsaw power requirements only. When the power necessary to drive auxiliary equipment is considered—carriage 10–15 h.p., trim saw 3–5 h.p., edger 15–20 h.p., and conveyers 2 h.p.—additional 30 to 40 h.p. is required. This means that at least 100 h.p. is required to operate all of the machinery in the mill.

The species and sizes that can be sawn by a circular mill with similar equipment to that of the research sawmill (circular headrig, edger, trim saws) and with 100 horsepower are shown on the left-hand side of the oblique line drawn across Table 2. For instance, the maximum size white pine log that can be sawn without the mill being underpowered is 14 inches, as compared to a maximum of 10 inches for tamarack, 8 inches for yellow birch, and 6 inches for white oak.

B. Efficient Use of Power: While a saw speed of 700 r.p.m. and a carriage speed of 170 ft./min. are very common in circular mills, tests with various feed and saw speeds showed that power is used more efficiently at other combinations of saw and feed speeds.

Saw speed and carriage feed speed are interdependent and between them determine the bite per tooth. If the saw speed is held constant and the carriage feed speed is increased, then the bite per tooth is increased. If the carriage feed speed is maintained at a constant rate and the saw speed is decreased, then the bite per tooth is increased. Similar amounts of bite can, of course, be obtained at different saw and carriage speeds, i.e., a bite of .077 inches per tooth is obtained at 170 ft./min. and 700 r.p.m., at 97 ft./min. and 400 r.p.m., and at 243 ft./min. and 1,000 r.p.m.

As the saw speed is increased and the carriage speed held constant, the power requirements are increased. The effect of increased saw speeds is shown in Figure 8. For instance, at a saw speed of 400 r.p.m. and a feed of 140 ft./min., power requirements for an 8-inch white pine cant are 28 h.p. compared to 34 h.p. at 700 r.p.m. and 40 h.p. at 1,000 r.p.m. Of course, as the saw speed is increased while the carriage speed is held constant, bite per tooth is decreased and actually each tooth is taking out a smaller amount of wood during each revolution of the saw. The wood (sawdust) is, therefore, being ground to finer particles which would be expected to increase power requirements. Therefore, for similar carriage speeds less power is used to saw lumber at the lower saw speeds, because at these slower saw speeds bite per tooth is increased and the sawdust particles are not so finely divided.

Figure 8 shows power requirement figures only, for various combinations of saw and carriage speeds. A more valuable comparison may be obtained by calculating the amount of "work" (force times distance) performed at various combinations of saw and carriage speeds. This is presented in Figure 9. This figure is based on 8-inch white pine cants having a specific gravity of 0.326 to 0.375. At a carriage speed of 170 ft./min. and a saw speed of 700 r.p.m. the work required to saw a length of 1 foot is 7665.7 ft. lbs. This unit has been plotted on Figure 9 as a horizontal black line to enable comparisons to be made easily.

It is apparent from Figure 9 that by reducing saw speed from 1,000 to 700 r.p.m. or from 700 to 400 r.p.m. and retaining the carriage speed of 170 ft./min. a decrease in "work" of the order of 18 per cent is obtained, with a consequent increase in mechanical efficiency in each case, and a resultant saving of power.

Since the slower saw speed entails a greater chip thickness per tooth (and consequently a greater stress effect on the teeth), a test was conducted to de-

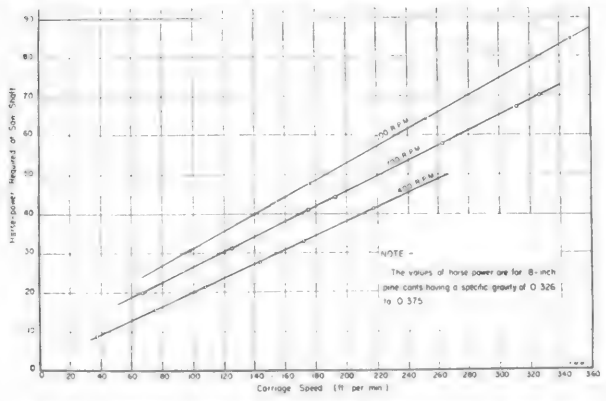

Horsepower Required at Saw Shaft
Carriage Speed (ft per min)
1000 R.P.M.
700 R.P.M.
400 R.P.M.
NOTE -
The values of horse power are for 8-inch pine cants having a specific gravity of 0.326 to 0.375

Fig. 8.—Relation between horsepower and carriage speed, for three saw speeds.

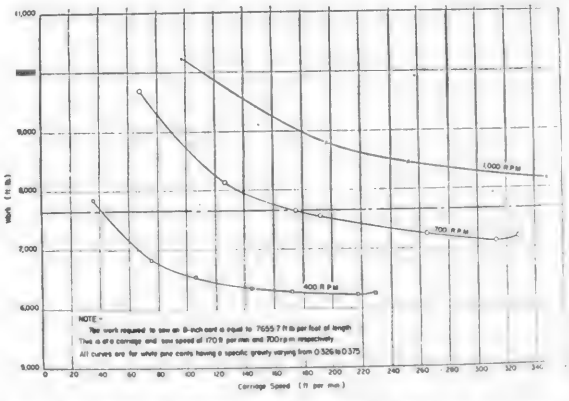

Work (ft lb)
Carriage Speed (ft per min)
1000 R.P.M.
700 R.P.M.
400 R.P.M.
NOTE -
All curves are for white pine cants having a specific gravity varying from 0.326 to 0.375

Fig. 9.—Relation between work required at saw and carriage speed, for three saw speeds.

termine the effect of a very large bite on the saw teeth (a bite of up to 0.175 inches per tooth).

Several thousand board feet of white pine were sawn and observations were made with regard to the heating of the saw, the ability of the teeth to withstand the heavy bite, and the quality of sawing. No deviations were apparent from so-called normal saw and teeth action, and the quality of sawing had not apparently suffered. It is also apparent that by retaining a saw speed of 1,000, 700, or 400 r.p.m., and by varying the carriage speed, a change may be effected in the amount of work involved. At slow feed speeds, the amount of work is greater (at each of the three saw speeds) than at faster feeds.

Application

The results of these studies on power requirements can be used in two ways. First, an accurate picture of the headsaw power requirements for sawing various species will be of value both in the use of present equipment and in the purchase of new equipment. Second, where difficulty in sawing is experienced owing to insufficient power, a slow saw speed coupled with a fairly fast feed rate will enable an efficient use of the available power to be made.[3]

In turn this will tend to minimize the slowing of the saw in the cut, overheating, and rim flutter. Consequently, more accurate lumber may be sawn without decreasing the rate of production. For example, if a mill operating at 700 r.p.m. and 170 ft./min. experiences a marked slowing down of the saw in a normal depth of cut, a more efficient use of the power available (18 per cent saving) could be made at a saw speed of 400 r.p.m. and a similar carriage speed of 170 ft./min.

If sufficient power is available, an increase in production may be possible by maintaining a fairly high saw speed and increasing the feed speed of the carriage. For example, it can be seen from Figure 9 that the carriage speed of a mill operating at 700 r.p.m. and 170 ft./min., could be increased to 250 ft./min. with a 5 per cent increase in efficiency. Although this increase in efficiency will require more power, the disadvantage of the need for extra power consumption may be more than offset by the advantage of increased production resulting from the higher feed speed.

A feed speed of over 220 ft./min. does not appear practical at a saw speed of 700 r.p.m. with present saws because of the fast rate of sawdust production and the tendency of the large volume of sawdust to clog the gullets. However, in many small mills, feed speeds of 300 ft./min. are quite practical at 700 r.p.m. and also at 1,000 r.p.m.

The above efficiency calculations are preliminary and are based only on green white pine cants, the maximum size of which was not greater than 10 inches.

Further studies will be directed towards determining the optimum combination of saw and carriage speeds for a variety of species and a range of sawlog sizes.

7. Effect of Various Types of Saw Teeth on Sawing: The research sawmill recently has been experimenting with inserted teeth which possess a hollow ground cutting face. Initial experiments comparing these types with a normal or standard type showed that a considerable saving in power (14 per cent) and a better surface quality could be obtained.

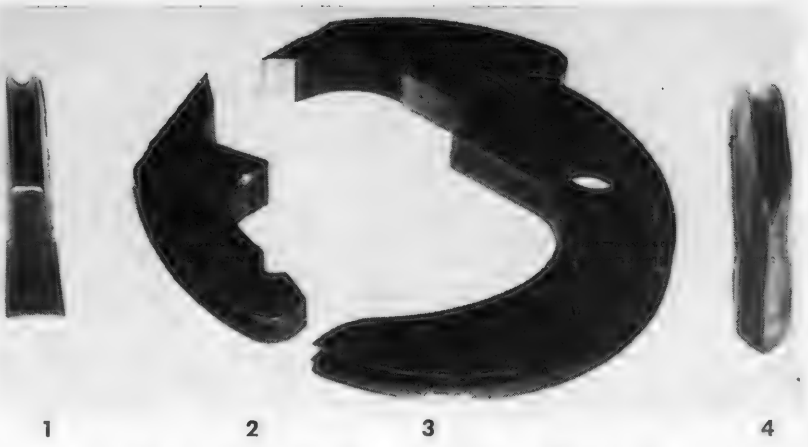


Fig. 10.—Types of teeth used on study. 1) Hollow ground. 2) Chipbreaker No. 2. 3) Chipbreaker No. 1. 4) Diamond point.

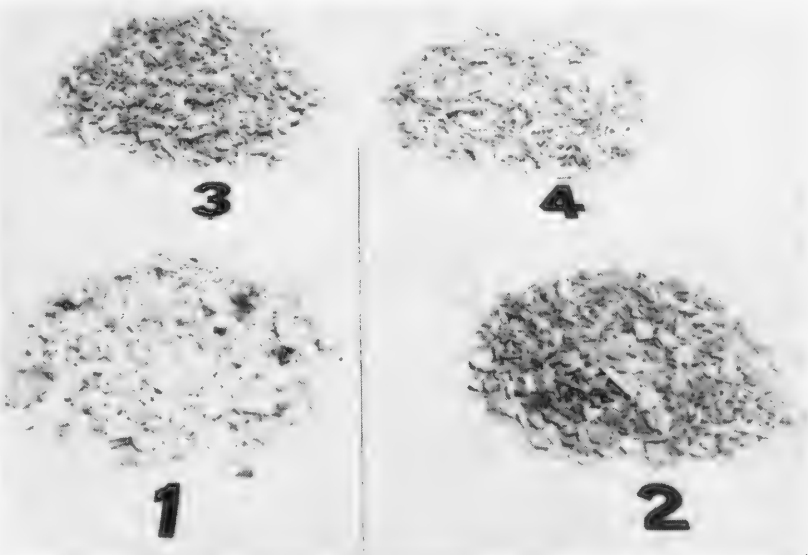


Fig. 11.—Samples of sawdust from various types of teeth. 1) Normal. 2) Diamond point. 3) Chipbreaker No. 1. 4) Chipbreaker No. 2. Note the fine sawdust by chipbreakers 1 and 2, and the distinctive shape of sawdust from each type of tooth.

As a result of these tests, studies were undertaken to determine the most efficient amount of hollow grinding and at the same time to evaluate the efficiency of hollow ground teeth as compared to various other types of teeth recently developed. This test deals with the following types of inserted teeth:

(a) Hollow ground ½″ radius
(b) Hollow ground 1″ radius
(c) Hollow ground 2″ radius
(d) Hollow ground 3″ radius
(e) Diamond point type
(f) Chipbreaker type No. 1
(g) Chipbreaker type No. 2

The last two possess shoulders to break the sawdust into small particles, presumably leading to easier ejection and lower power requirements. The former has the shoulder located on the tooth holder, whereas in the latter the shoulder is an integral part of the tooth itself (Figure 10).

[3] It is understandable when it is realized that although carriage speed and consequently bite are increased, the reduction in saw r.p.m. lessens power consumption to such a degree that it more than compensates for the power increase due to increasing carriage speed.

The tests were conducted on 56 logs, 14 each of sugar maple, yellow birch, white pine, and white spruce. Suitable controls were established which enabled the variation in power requirements to be broken down into its primary components, i.e., power requirements due to species and power requirements due to teeth. The results are based on 672 saw cuts obtained from the 56 logs.

Results

Table 3 has been developed to show the power required to saw the species used in the test. This is a composite table and represents average power requirements for all species, for each type of teeth.

Table 3.—AVERAGE POWER REQUIREMENTS FOR ALL SPECIES SAWED

Tooth	Mean H.P.
Chipbreaker type No. 1	59.4
Chipbreaker type No. 2	57.1
Diamond point type	56.2
1″ Hollow Ground	55.3
2″ Hollow Ground	55.2
3″ Hollow Ground	54.2
½″ Hollow Ground	47.5

Using a statistical method involving the differences between these means, an estimate was obtained as to the significance of these differences. Based on this method of analysis, the following conclusions may be formed:

1. Of the teeth tested the most efficient was found to be those which had been hollow ground with ½″ radius. This was probably due to the cutting rather than the tearing action of the teeth on the sides of the cut.
2. The least efficient type of tooth was the chipbreaker. The shoulder on the tooth holder of type 1 and on the tooth of type 2 break the sawdust into extremely fine particles (Figure 11). This process appears to require additional power as is shown by the significantly high power requirements for these two types.

It was difficult to assess the quality of finish in the softwoods and no definite conclusions could be formed. However, there appeared to be noticeable improvement in surface quality of the hardwood lumber sawn with hollow ground teeth. It was impossible to distinguish any difference in lumber quality sawn by the three types of hollow ground teeth—each type producing a similar finish.

Other Applied Research

In addition to these tests of a more or less fundamental nature, investigations of an applied nature have been carried on. These latter include developmental work on an inexpensive log turner, an adjustable gauge to compensate for inaccuracies in the setworks, and construction of a shadow line projector for the edger. Reports which have been completed on these subjects are available from the Ottawa Laboratory, Forest Products Laboratories of Canada.

Swelling of Paint Films in Water

V. Effects of Different Pigments[1]

F. L. BROWNE

Chemist, Forest Products Laboratory,[2] Forest Service, U. S. Department of Agriculture

Describes measurements of absorption, swelling, and related data for free films of single-pigment paints tested by soaking in distilled water for three days both before and after artificial weathering for 15 days. Forty-four pigments tested and classified.

TO DETERMINE THE EFFECTS of different pigments on the behavior of free films of paint when soaked in water, 44 single-pigment paints of 0.30 pigment volume in linseed oil were made and tested before and after artificial weathering for 15 days.

Changes in density during drying and weathering gave evidence of a varying effect of pigments on oxidation of linseed oil. Losses in weight during weathering were due, first, to leaching of soluble organic and inorganic materials and, later on, to mechanical losses by chalking.

Some pigments reduced the absorption of water and swelling of free films below the absorption and swelling of unpigmented linseed oil, whereas others increased absorption and swelling, sometimes greatly. The effects of the pigments on absorption of water seem to be connected with their effects on the oxidation of linseed oil.

Weathering tends to make some films porous so that part of the water they take up is free water in pores that causes no swelling. Measurements were made of swelling in volume, area, and thickness, and of shrinkage in volume, area, and thickness, from which further indications of the film structure and effect of weathering were obtained.

Soluble substances derived from decomposition of linseed oil and sometimes from the pigments, were extracted from paint films during the 3-day period of soaking in water.

Previous papers in this series described the technique of preparing free films of weathered and unweathered house paints and of measuring their absorption of water and swelling when soaked in distilled water for 3 days, together with the changes in density, the shrinkage on redrying after soaking, the loss of soluble substances to the soaking water, and the losses in weight during artificial weathering in a Weatherometer (5).[3] The effects on absorption and swelling of such factors as time of soaking in water, temperature and pH of soaking water, age of films before soaking, thickness of films, pigment volume of the paints, and both artificial and natural weathering were reported.

Data were given for some unpigmented paint vehicles and for laboratory-made and commercial paints of widely differeing compositions (4, 7). Absorption and swelling of free films of vehicles and paints when exposed to air of different relative humidities were measured (6).

Dunn (10) has reported measurements of the absorption of water, swelling in area, and solubility of free films

[1] A contributed paper.

[2] Maintained at Madison, Wis. in cooperation with the University of Wisconsin.

[3] Numbers in parentheses refer to literature cited.

The Author, Frederick L. Browne, received B.Chem. degree from Cornell University, Ph.D. in colloid chemistry from University of Wisconsin. He first joined the Forest Products Laboratory staff in 1918, helped develop casein glues for wood airplanes of World War I. In 1921–22 he was a National Research Fellow at Wisconsin. Since 1929, Dr. Browne has edited the General and Physical Chemistry section of Chemical Abstracts.

of single-pigment linseed oil paints made with white lead, zinc oxide, titanium dioxide, and magnesium silicate, of multiple-pigment paints, and of unpigmented linseed oil and various resinous vehicles. His findings are similar to those described in this series of papers.

In house paints made with linseed oil, the most important factor determining the absorption and swelling in water proves to be the kind of pigments with which the paint is made.

Pigments and Paints Tested

All pigments except mica and aluminum, which are "leafing" pigments, were tested in linseed-oil paints of pigment volume 0.30 made according to the following general formula:

Pigment	0.261 gallon
Raw linseed oil	.609 gallon
Lead-manganese naphthenate liquid drier	.020 gallon
Mineral spirits	.110 gallon
Total	1.000 gallon

The aluminum paint consisted of 2 pounds of commercial aluminum paste (75 per cent aluminum powder, 25 per cent mineral spirits) in 1 gallon of bodied-linseed-oil vehicle (66.5 per cent bodied linseed oil, 33.5 per cent mineral spirits and lead-manganese drier, viscosity B). The mica paint consisted of 2 pounds of a commercial surface-treated mica in 1 gallon of the bodied-linseed-oil vehicle.

In commercial practice, basic carbonate white lead is commonly used for house painting as a single-pigment paint, of which the paint tested is representative. The aluminum paint was also a commercially practicable paint. All of the other pigments, however, are used in house paints only as admixtures with other pigments in making mixed-pigment paints. For the present study, however, the purpose was to learn the effect of each pigment by itself on the absorption and swelling of paint films.

Although all of the pigments tested are purchasable under the names by which they are designated, they are not all single chemical compounds. The following are either "composite" pigments or naturally occurring mixtures.

Leaded zinc oxides are mixtures of basic lead sulfate and zinc oxide; those tested were cofumed products, that is, mixtures condensed together from the gas phase in the process of manufacture. Basic silicate white lead is a composite of basic lead sulfate and silica said to consist of granules of silica firmly coated with the basic lead sulfate. Lithopone is a mixture of zinc sulfide and calcium sulfate precipitated together from aqueous solution in manufacture. Titanium-calcium pigment is a mixture of rutile titanium dioxide precipitated in a slurry of calcium sulfate. Venetian red is a mixture of ferric oxide and calcium sulfate made by calcining together ferrous sulfate and calcium carbonate.

The manufactured and natural iron-oxide reds contain siliceous minerals present in the ore from which the pigments are made. Some of the titanium dioxides contain small additions of other substances deliberately incorporated to control the chalking properties of paints made with the pigments. Other pigments may contain small proportions of extraneous substances classifiable as impurities.

Other comments about the pigments tested are the following: Antimony oxide is an opaque white pigment used for house paints more widely in Europe than in the United States. Lead titanate is a slightly yellowish opaque white pigment formerly used in house paints but no longer available in the American market. Dibasic lead phosphite is an opaque white pigment recently developed primarily for use in vinyl resins and chloriated hydrocarbons but with properties that might well prove useful in house paints.

Basic carbonate white lead Nos. 1 and 2 were products of the same manufacturer. No. 1 was higher in ratio of lead hydroxide to lead carbonate than No. 2.

Of the two leaded zinc oxides tested, one is a pigment that has long been in use in house paints; the other, 18 per cent leaded zinc oxide, is a recent development in which an unusually high proportion of the lead component is said to be in a form available for reaction with acids formed in the paint vehicle.

Four of the five lead-free zinc oxides tested were chosen to represent the range in reactivity of the zinc oxide pigments made in the United States. Ten widely used brands were tested for their rate of reaction with meso-tartaric acid in aqueous medium. Zinc oxide No. 1 was the brand found slowest in reaction, zinc oxide No. 4 was the fastest in reaction, and Nos. 2 and 3 were intermediate. Relative rates of reaction were expressible by the figures 1.65, 3.70, 5.15, and 7.10 for zinc oxides Nos. 1, 2, 3, and 4 respectively.

Zinc oxide No. 1 was of large and No. 4 was of fine particle size. Zinc oxide No. 5 was an experimental product made in accordance with a suggestion by a manufacturer of silicone in the following manner: commercial zinc oxide No. 2 was slurried in a 1 per cent aqueous solution of vinylsilane containing 0.02 per cent of sodium hydroxide and was then filtered and dried at 105° C. The treatment was said to make zinc oxide water repellent.

Titanium dioxide Nos. 1, 3, and 4 were products of one manufacturer, and Nos. 2 and 5 of another manufacturer. Nos. 1 and 2 were of the anatase crystal structure; 3, 4, and 5 of the rutile crystal structure. Nos. 1, 2, and 3 were said to contain no modifying agents, but Nos. 4 and 5 contained not more than a total of 6 per cent of alumina, silica, and zinc oxide incorporated in manufacture to give maximum resistance to chalking.

Lead chromate and zinc chromate are bright yellow pigments. Basic lead chromate is bright orange in color. The ferric oxide pigments and Venetian red are red in color. Ferric oxide Nos. 1 and 2 were manufactured pigments from 2 different makers, and No. 3 was a naturally occurring iron ore known as Spanish oxide. Ferric hydroxide yellow was a manufactured pigment of dull yellow color. Zinc dust is dark gray in color without metallic luster, but aluminum pigments are light gray with high luster.

Magnesium silicate Nos. 1 and 2 came from different producers. Calcium carbonate Nos. 1 and 2 were surface-treated pigments from different makers. Calcium carbonate Nos. 3 and 4 were naturally occurring products of which No. 3 was of relatively coarse particle size and remarkably low oil absorption, and No. 4 was typical of the pigments called whiting.

Diatomaceous silica is a porous pigment consisting of the skeletons of diatoms found in what were ocean beds in former geologic times. The treated bentonite was dimethyloctadecyl ammonium bentonite made by cation exchange between the organic base and the naturally occurring montmorillonite (clay) known as bentonite; it is a recent development used as a gelling agent in paints. Magnesium silicate, calcium carbonate, barium sulfate, calcium sulfate, silica, diatomaceous silica, treated bentonite, and mica are all pigments of low opacity that make transparent or nearly transparent coatings when made into paints with linseed-oil vehicle.

Preparation of Free Films and Tests

To prepare unweathered films, the paints were spread on gummed paper by doctor blade and suction plate at a thickness designed to make coatings approximately 4 mils thick when dry. Actually 36 of the 44 films reported in Table 1 were within 0.5 mil of the desired thickness. The films were stripped from the gummed paper when they were 7 or 8 days old, and the soaking tests were started when they were 10 days old.

To prepare weathered films, the paints were spread on tared tinplate by doctor blade and suction plate to make coatings approximately 4 mils thick. When 10 days old, the coated tinplate specimens were weighed to find the weight of coating and were then sub-

jected to artificial weathering for 15 days in a Weatherometer. Distilled water was supplied to the Weatherometer sprays. After weathering, the specimens were weighed to determine the loss in weight of the coatings during weathering. The films were then stripped from the tinplate by amalgamation and promptly submitted to soaking tests.

For details of the testing technique and methods of expressing results, reference should be made to a previous paper (5).

Unweathered Films

The results obtained with unweathered films are reported in Table 1.

Density Changes: All paints increased significantly in density when the liquid paint hardened to a dry coating. The increase in density, however, was always less than that calculated from the increase in density and in weight of the linseed oil in the paint, assuming that the changes in the oil of the paints are the same as for unpigmented linseed oil.

Data of Carrick and Permoda (8) indicate that 10-day-old linseed-oil films have a density of 1.12 and are 4.45 per cent heavier than the original, undried oil. Data in the second paper of this series (5) agree about the density of 1.12.

If the oil in the antimony oxide paint of Table 1 had reached the same condition 10 days after spreading, the density of the film would have been 2.64, which exceeds the density of 2.54 actually found by 0.10. Similar calculations for all of the other paints of Table 1 reveal differences in the density, as calculated and as determined, that range from 0.01 to 0.26.

Rhodes and coworkers (15, 16) showed that some pigments greatly alter the absorption of oxygen and evolution of volatile matter from paint films over a length of time that included the 10-day period, whereas other pigments exert much less effect. Silica, iron oxide, and Venetian red were pigments that had little effect. For all of them the discrepancy between the calculated and determined density in Table 1 was less than 0.10.

On the other hand, Rhodes found large effects for basic carbonate and basic sulfate white lead, lithopone, titanium-barium pigment, barium sulfate, leaded zinc oxide, and zinc oxide. For all of them the discrepancy between calculated and determined density in Table 1 was 0.10 or greater. It is, therefore, reasonable to attribute the differences between calculated density and density actually found to the effect of pigments on the oxidation of linseed oil.

The pigments in Table 1 for which the difference between calculated and determined density of paint films was less than 0.10 were: basic silicate white lead, dibasic lead phosphite, 18 per cent leaded zinc oxide, zinc sulfide, zinc chromate, titanium dioxide Nos. 1, 2, and 3, titanium-calcium, all iron oxide and iron hydroxide pigments including Venetian red, both magnesium silicates, all calcium carbonates, calcium sulfate, silica, and treated bentonite. The aluminum and mica paints cannot be considered in this connection because they were made with bodied linseed oil and have a different paint structure. For paints made with all the other pigments, the differences between the calculated and determined densities were 0.10 or more.

It is of interest that the 2 paints made with titanium dioxide Nos. 4 and 5, both of which contained small amounts of zinc oxide, exhibited higher density difference than the other titanium dioxides.

The density of all paint films decreased when they absorbed water during the 3-day soaking period. After redrying, the density usually returned to a value slightly greater than that just before soaking. By that time, of course, the paints were 4 or 5 days older. Paints made with calcium sulfate, titanium-calcium, and Venetian red, which contained calcium sulfate, lost part of the calcium sulfate by leaching while soaking, and on redrying they failed to attain a density greater than that before soaking.

Zinc oxide No. 5, which was treated with vinyl silane, and zinc chromate, ferric oxide No. 1, and calcium carbonate Nos. 1 and 2 all made paints that lost much of the soluble pigment ingredients during soaking. After redrying, they remained lower, or at least no higher, in density than they were before soaking. The paints made with 35 per cent leaded zinc oxide and with treated bentonite were anomalous in that the density after redrying was no higher than before soaking, although the leaching losses were only moderate.

Absorption of Water: In the second paper of this series (5) the absorption of water by unpigmented raw linseed oil on soaking for 3 days was reported as approximately 20 per cent. Since the paint films reported here contained 70 per cent linseed oil by volume, they would be expected to absorb 14 per cent of water if the pigment present had no effect beyond reducing the volume of oil in 1 cubic centimeter of film.

Table 1 shows that paints made with the following pigments were significantly less absorptive than unpigmented linseed oil: antimony oxide, lead titanate, the white leads including the basic carbonates, basic sulfate, and basic silicate white lead, dibasic lead phosphite, lead chromate (but not basic lead chromate), barium sulfate, silica, mica, and aluminum.

In addition, paints with the following pigments were either slightly less, or only slightly more, absorptive than unpigmented linseed oil: basic lead chromate, titanium dioxide Nos. 1, 2, and 3, which contained no zinc oxide, ferric oxide No. 2 (but not Nos. 1 or 3), ferric hydroxide, and coarse particle-size calcium carbonate No. 3 (but not calcium carbonate Nos. 1, 2, and 4).

All other pigments made paints of greater absorptiveness than unpigmented linseed oil. Zinc oxides, leaded zinc oxides, and zinc chromate made paints of very high absorption, from 74.5 to 117 per cent. Other pigments that made highly absorptive paints were ferric oxide No. 1, Venetian red, and calcium carbonate Nos. 1, 2, and 4.

Zinc sulfide, lithopone, and zinc dust made paints that absorbed 39.9 to 45.5 per cent of water—significantly more than unpigmented linseed oil but only about half as much as zinc oxide paints. Among the titanium dioxide pigments the 2 (Nos. 4 and 5) in which small quantities of zinc oxide were incorporated by the maker to reduce chalking made paints of distinctly higher absorptiveness than the 3 in which there were no such additives.

Calcium sulfate and the pigments that contained calcium sulfate, titanium-calcium, and Venetian red, made paints of moderately high (about 35 per cent) or very high (87.5 per cent) absorptiveness. Magnesium silicate paint films absorbed 56.2 to 69.6 per cent of water.

The extreme variation in absorptiveness among the 3 ferric oxide pigments, 22.4, 31.4, and 110 per cent, respectively, is as yet unaccountable, as are the differences among the 4 calcium carbonates, from 24.5 to 117 per cent absorption. Diatomaceous silica made paint of slightly higher absorption than unpigmented linseed oil, whereas ordinary silica gave low absorption.

It is not yet possible to relate the effect of pigments on the absorption of water by paint films to other physical or chemical properties of the pigments. Chemical reactivity in the sense of soap formation between basic pigments and free acids or acid decomposition products of the oil is not a determining factor because unreactive silica or barium sulfate, as well as reactive white leads, reduce absorption below that of unpigmented linseed oil; whereas unreactive magnesium silicates and titanium dioxides, as well as reactive zinc oxides, increase absorption.

Furthermore, the great variation in chemical reactivity of the 4 unleaded zinc oxides was not paralleled by similar variation in absorption. In fact, the

Table 1.—DATA FOR FREE FILMS OF SINGLE-PIGMENT PAINTS BEFORE WEATHERING—CHANGES IN DENSITY; ABSORPTION OF WATER AND SWELLING IN VOLUME, AREA, AND THICKNESS WHEN SOAKED IN WATER FOR THREE DAYS; SWELLING EFFICIENCY; SHRINKING IN VOLUME, AREA, AND THICKNESS WHEN REDRIED; AND LOSS IN WEIGHT BY LEACHING DURING THE SOAKING PERIOD

Paint	Density of: nonvolatile in liquid paint	Density of film: Dry	Swollen in water	Redried	Initial thickness: T_o	Absorption of water: A/V_o	Swelling: In volume ΔV_s	In area: ΔQ_s	In thickness: ΔT_s	Swelling efficiency: $\frac{\Delta V_s V_o}{A}$	Redried: Volume ΔV_r	Area ΔQ_r	Thickness ΔT_r	Loss in weight soaking S_2/V_o
					Mils	Percent	Percent	Percent	Percent	Percent	Percent	Percent	Percent	Percent
Antimony oxide	2.38	2.54	2.52	2.61	3.4	5.3	5.8	2.9	0.3	109	-4.3	-1.4	-2.9	4.7
Lead titanate	2.84	2.98	2.89	3.04	4.0	7.8	7.5	4.7	.7	96	-2.9	-.5	-2.0	3.2
Basic carbonate white lead No. 1	2.67	2.84	2.71	2.90	3.9	10.7	10.8	6.0	1.6	101	-3.3	+1.0	-3.6	4.8
Basic carbonate white lead No. 2	2.70	2.87	2.74	2.90	3.8	8.9	9.3	2.1	5.3	104	-2.5	+.1	-2.1	3.8
Basic sulfate white lead	2.57	2.74	2.59	2.78	4.2	9.7	11.6	7.4	1.7	120	-3.2	-.7	-2.4	3.8
Basic silicate white lead	1.86	2.01	1.92	2.03	4.2	10.1	10.5	5.9	2.2	105	-3.0	+1.4	-4.3	4.1
Dibasic lead phosphite	2.74	2.97	2.78	3.01	3.6	11.7	12.1	3.8	6.7	103	-1.5	+.3	-2.8	1.3
Lead chromate	2.40	2.58	2.44	2.61	4.1	11.4	11.5	6.3	2.4	101	-2.9	-.2	-2.7	3.6
Basic lead chromate	2.72	2.78	2.45	2.79	4.1	24.0	23.3	13.7	7.2	97	-1.8	+1.5	-3.1	3.1
35 percent leaded zinc oxide	2.45	2.58	1.76	2.42	4.1	111	108	61.3	29.0	97	+4.8	+25.2	-16.2	4.3
18 percent leaded zinc oxide (reactive)	2.38	2.55	1.89	2.59	3.4	74.5	74.5	47.0	16.4	100	-3.4	+18.1	-18.1	5.4
Zinc oxide No. 1	2.34	2.48	1.86	2.53	3.7	74.6	74.6	42.7	20.0	100	-3.9	+9.4	-12.0	5.6
Zinc oxide No. 2	2.33	2.44	1.80	2.47	3.7	83.3	81.6	28.4	39.2	98	-3.6	+5.0	-8.0	5.9
Zinc oxide No. 3	2.34	2.47	1.72	2.48	4.1	106	105	70.8	19.2	99	-2.0	+32.5	-26.1	4.2
Zinc oxide No. 4	2.34	2.47	1.75	2.48	4.1	82.0	87.3	22.9	54.4	106	-2.9	-3.3	+.5	6.4
Zinc oxide (treated) No. 5	2.33	2.40	1.66	2.17	3.3	117	112	50.5	41.0	96	+7.2	+20.5	-10.9	7.4
Zinc sulfide	1.86	2.00	1.73	2.02	3.8	39.9	40.3	24.0	11.2	101	-2.7	+3.8	-6.0	2.7
Lithopone	1.94	2.07	1.74	2.10	3.7	45.5	45.9	27.1	12.9	101	-2.5	+5.7	-7.3	2.9
Zinc chromate	1.69	1.83	1.43	1.82	3.9	88.5	87.4	45.1	26.4	99	-4.7	+15.4	-17.5	9.9
Zinc dust	2.76	3.64	2.86	3.70	3.4	43.2	43.3	25.9	12.4	100	-2.5	+2.3	-4.7	3.6
Titanium dioxide (anatase) No. 1	1.82	1.95	1.83	1.99	3.7	17.3	17.9	9.2	4.0	103	-3.7	+.5	-4.5	3.7
Titanium dioxide (anatase) No. 2	1.82	1.98	1.79	2.02	3.5	26.6	27.2	13.5	8.2	102	-4.9	+1.4	-6.2	5.3
Titanium dioxide (rutile) No. 3	1.92	2.06	1.92	2.08	4.0	16.5	17.2	9.8	4.5	104	-2.8	0	-4.5	2.8
Titanium dioxide (rutile) No. 4	1.92	2.03	1.37	2.06	4.0	30.3	30.7	16.5	10.4	101	-2.7	+1.6	-4.0	2.2
Titanium dioxide (rutile) No. 5	1.91	2.06	1.80	2.11	3.5	34.9	35.5	17.1	12.4	102	-4.2	+3.3	-7.1	4.1
Titanium-Calcium	1.63	1.75	1.54	1.75	3.9	35.4	35.6	17.8	10.7	101	-5.3	+2.7	-7.4	9.9
Ferric oxide red (manufactured) No. 1	2.06	2.23	1.59	2.22	3.8	110	108	58.4	29.6	98	-2.5	+12.3	-13.5	7.5
Ferric oxide red (manufactured) No. 2	2.16	2.32	2.11	2.38	3.7	22.4	22.9	9.5	9.1	102	-4.1	-.2	-3.5	4.2
Ferric oxide red (natural) No. 3	1.99	2.14	1.84	2.16	3.9	31.4	36.5	17.8	13.5	116	-3.1	+2.8	-5.6	4.2
Venetian red	1.82	1.99	1.49	1.83	4.6	87.5	81.0	48.3	22.2	93	0	+9.8	-9.1	15.9
Ferric hydroxide yellow	1.87	2.00	1.88	2.04	3.3	16.4	16.4	7.1	5.7	100	-3.4	-.8	-2.4	4.4
Magnesium silicate No. 1	1.51	1.68	1.44	1.70	2.9	56.2	56.1	13.7	37.3	100	-3.8	+2.2	-5.8	4.5
Magnesium silicate No. 2	1.51	1.62	1.37	1.63	3.7	69.6	69.3	20.4	39.2	99	-2.2	+4.3	-6.2	3.0
Calcium carbonate No. 1	1.46	1.58	1.33	1.51	3.8	71.8	66.5	46.9	11.9	93	-2.9	+17.6	-17.3	11.6
Calcium carbonate No. 2	1.46	1.58	1.28	1.58	4.1	104	103	57.9	26.4	99	-4.0	+14.9	-16.2	5.8
Calcium carbonate No. 3	1.47	1.60	1.49	1.62	4.5	24.5	24.7	12.7	7.5	101	-3.4	+.5	-3.8	4.1
Calcium carbonate No. 4	1.46	1.54	1.26	1.55	3.6	117	107	64.5	23.1	92	-4.6	+18.2	-19.2	6.3
Barium sulfate	1.97	2.06	1.98	2.09	4.7	11.4	11.1	8.6	0	97	-2.7	+.9	-3.4	2.2
Calcium sulfate	1.36	1.47	1.19	1.23	3.8	36.8	33.4	10.7	6.3	91	-20.4	-4.7	-16.2	50.5
Silica	1.45	1.56	1.52	1.57	4.8	9.3	9.7	5.5	1.9	104	-2.6	-.5	-2.1	2.1
Diatomaceous silica	1.25	1.31	1.29	1.33	4.7	28.7	25.1	10.0	10.7	87	-3.2	+.2	-3.4	3.0
Treated bentonite	1.19	1.26	1.20	1.26	3.3	30.9	30.9	17.2	9.2	100	-2.9	+3.2	-5.8	3.6
Mica in bodied oil	1.18	1.30	1.27	1.32	3.0	11.6	12.4	.9	7.0	107	-4.6	+.1	-5.4	4.0
Aluminum in bodied oil	1.11	1.21	1.20	1.23	2.7	9.3	10.1	1.8	1.5	109	-7.2	-.4	-6.9	6.8

most rapidly reactive zinc oxide, No. 4, made paint little more absorptive than the least reactive zinc oxide, No. 1, and less absorptive than No. 2, which was about half as rapidly reactive.

On the other hand, basic carbonate white lead No. 1 contained a higher proportion of reactive lead hydroxide and made paint slightly more absorptive than basic carbonate white lead No. 2, and basic lead chromate made more absorptive paint than neutral lead chromate.

Solubility of pigments or pigment ingredients may be a minor factor that increases absorption, as in the cases of calcium sulfate, Venetian red, calcium carbonate, and zinc chromate, but such nearly insoluble pigments as the titanium dioxides increase absorption at least moderately.

The dominant effect of pigments, including nonreactive and insoluble pigments, indicates that the interface between pigment and oil is the seat of the unknown mechanism by which absorption is chiefly governed. But the area of interface, which increases greatly as the size of the pigment particles diminishes, seems to be of secondary importance. Zinc oxide No. 4, which was of exceedingly fine particle size (about 0.12 micron), made paint less absorptive than zinc oxide No. 2, which was much coarser, and little more absorptive than the zinc oxide No. 1, which was of relatively coarse particle size (about 1 micron).

The titanium dioxides, though finer in particle size than zinc oxide No. 1, made much less absorptive paints. The white lead pigments were comparable in particle size to zinc oxide No. 1, but made paint of much lower absorption. Among the calcium carbonate pigments, the one of coarsest particle size, No. 3, made the least absorptive paint, but it was higher in absorption than such paints as those made with the white leads and lead titanate with much finer particle size.

Likewise, particle shape seems to be unimportant because the paint made with markedly acicular zinc oxide No. 2 fell between the paints made with distinctly nodular zinc oxide Nos. 3 and 4, and the paints with acicular magnesium silicates fell within the range of absorptiveness of the calcium carbonate paints with nodular pigments.

It is reasonable to suppose that water absorbed by pigmented paints in excess of that taken up by unpigmented linseed oil is held chiefly at the interface between pigment and oil, at least when the pigments do not react to form oil-soluble products diffused through the vehicle. If so, a relation might well be expected between absorption of water by films and adsorptive properties of pigments, or between absorption of water by films and the interfacial tensions between pigment and water and pigment and oil. Gardner (11) published data on the adsorption of methylene blue from aqueous solution by pigments; and Gardner (12) and MacGregor (14) reported tests of the distribution of pigments between water and organic liquids, including linseed oil, but no significant parallels can be found between either of these pigment properties and the absorption of water by paint films in the present tests.

Bartell and coworkers (1, 2) studied the interfacial tensions between pigments and liquids in great detail, but again there seems to be no clear relation between their findings and the effects

of pigments on the absorption of water by paint films.

The lack of agreement between the surface properties of pigments and the absorptiveness of paints made from them may be due to the change in chemical nature of liquid linseed oil as it is transformed into the linoxyn gel of dried paint films (3) and to the effect of pigments on that change.

The work of Rhodes and coworkers (15, 16), which has already been shown to be related to the increase in density during the drying of paints observed in these experiments, also proves roughly indicative of the absorption of water by the paint films. Basic carbonate white lead, basic sulfate white lead, and barium sulfate increased the consumption of oxygen and evolution of volatile matter in Rhodes' experiments, and they caused a reduction of the absorption of water by films in the present tests. Zinc oxide and leaded zinc oxide markedly reduced the consumption of oxygen and evolution of volatile matter and greatly stimulated absorption of water by films.

Lithopone and titanium-barium pigment moderately reduced the consumption of oxygen and evolution of volatile matter, and lithopone and titanium dioxide paint films exhibited moderate increase over unpigmented linseed oil in amount of water absorbed. Silica, which had little effect in Rhodes' experiments, made paint films of low absorption. There were variations among iron oxide pigments in both Rhodes' experiments and these. Venetian red reduced consumption of oxygen and evolution of volatile matter only slightly, but it made highly absorptive films. Iron oxides increased consumption of oxygen and evolution of volatile matter slightly to moderately, but they made moderately to highly absorptive paints.

But with the exception of the variable iron oxide pigments, the most anomalous one of which was not available at the time of Rhodes' work, there is a reasonably close parallel between the effect of pigments on the oxidation of linseed oil and the absorption of water by the films they produce. High absorption of water apparently comes from use of pigments that markedly reduce the consumption of oxygen and evolution of volatile matter when the paint has dried.

Swelling: For most of the unweathered films, the volumetric swelling during 3 days' soaking in water was nearly equal to the absorption of water. The swelling efficiency was therefore close to 100 per cent, a little greater than 100 per cent more often than less. The high efficiencies for paints made with antimony oxide, basic sulfate white lead, and aluminum in bodied oil could result from slight underestimation of the absorptions, which were small, from loss of moisture while weighing the wet films in air.

The film of paint made with iron oxide No. 3 gave high swelling efficiency with moderately high absorption, which suggests more serious experimental error. Low swelling efficiencies, less than 96 per cent, were found for films containing Venetian red, calcium carbonate Nos. 1 and 4, and calcium sulfate, all of which lost substantial proportions of pigment by solution in the soaking water, and diatomaceous silica, which has a highly porous pigment structure (7).

Swelling in area was always less than swelling in volume. All films, therefore, swelled also in thickness. The ratio of swelling in area to swelling in thickness, however, varied from 3.7 for zinc oxide No. 3 to 0.4 for zinc oxide No. 4, if only those pigments are considered for which the swelling was large enough to give confidence in the significance of the ratio. The swelling in area exceeded the swelling in thickness for 36 of the 48 pigments tested. There seems to be no recognizable connection between the ratio of areal to thickness swelling and other properties of the pigments.

In the first paper of this series (4), it was shown that most paints swell more across the grain of the paint than along the grain, especially when the paint contains markedly acicular pigments. The grain of the paint is determined by the direction of last flow of the liquid paint before it sets and begins to harden. The ratio of swelling in width (across the grain) to swelling in length, $\triangle B/\triangle L$, was greater than 2 for the following pigments in Table 1: dibasic lead phosphite, zinc oxide No. 2, ferric hydroxide yellow, magnesium silicate Nos. 1 and 2, and calcium sulfate, all of which have decidedly needle-shaped crystals.

Among the zinc oxides, No. 2, with acicular particles, gave a ratio $\triangle B/\triangle L$ of 4.0, but for zinc oxide Nos. 1, 3, and 4, with nodular particles, the ratios were 1.2, 1.0, and 1.0, respectively. But when acicular zinc oxide No. 2 was treated with vinyl silane, making zinc oxide No. 5, the ratio $\triangle B/\triangle L$ fell to 1.1. The treatment could not have altered the shape of the particles, but it probably resulted in clumping of the acicular crystals into larger aggregates of effectively spherical shape that were not dispersed by grinding into paint. In conformity with that view, the oil absorption of the pigment was very greatly increased by the treatment.

Pigments for which the ratio $\triangle B/\triangle L$ was greater than 1.2 but less than 2 were: antimony oxide (1.3), titanium–calcium (1.4), diatomaceous silica (1.5), and aluminum (1.8). For all other pigments in Table 1, the ratio was 1.0 to 1.2, except for titanium dioxide No. 2 and treated bentonite, for which the ratio was 0.9.

Shrinkage on Redrying: All films except those of the paints made with 35 per cent leaded zinc oxide, treated zinc oxide No. 5, and Venetian red shrank to less than their initial volume when they were redried after soaking in water. The 3 exceptions were films for which the swelling efficiency was less than 100 per cent, indicating the development of some degree of porosity, but not all films of low swelling efficiency remained swollen or failed to shrink on redrying.

Shrinkage to less than the initial volume on redrying may be attributed primarily to loss of soluble ingredients to the soaking water. The film of calcium sulfate paint, which lost 50.5 grams of soluable material per 100 cubic centimeters, chiefly calcium sulfate, shrank 20.4 per cent in volume when redried. For the other paints the volumetric shrinkage was 1.5 to 7.2 per cent.

In area, 33 of the 44 films remained larger after redrying than they were before soaking. In thickness, all films shrank after redrying, sometimes considerably, except that of zinc oxide No. 4. Its 0.5 per cent increase was small enough to be within experimental error. In general, therefore, unweathered free films after swelling seem to be able to shrink in thickness more readily than in area. That appears to be particularly true of films for which the swelling in water is large.

Loss in Weight While Soaking: All films lost weight during the 3 days of soaking in water. Unpigmented films of linseed oil lose 5 to 6 grams per 100 cubic centimeters of film (5), much but not all of which can be recovered by evaporating the soaking water to dryness. Volatile organic solutes, of course, are lost during evaporation and drying at 105° C.

Films of most of the paints in Table 1 lost 1.3 to 5.3 grams per 100 cubic centimeters of film. When the films contained insoluble, nonreactive pigments such as silica, magnesium silicate, barium sulfate, titanium dioxide, and lead titanate, the soluble ingredients consisted entirely of organic matter from the linseed-oil vehicle.

Likewise, the leachings from films containing any of the white leads or basic lead chromate contained organic matter with no more than a trace of soluble lead compounds. Any salts of lead formed by reaction with acids from decomposition of the linseed oil must, therefore, be nearly insoluble in water.

The films of paint made with calcium sulfate lost 50.5 grams per 100 cubic

Table 2.—DATA FOR FREE FILMS OF SINGLE-PIGMENT PAINTS AFTER ARTIFICIAL WEATHERING FOR 15 DAYS—LOSS IN WEIGHT WHILE WEATHERING; CHANGES IN DENSITY; ABSORPTION OF WATER AND SWELLING IN VOLUME, AREA, AND THICKNESS WHEN SOAKED IN WATER FOR THREE DAYS; SWELLING EFFICIENCY; SHRINKING IN VOLUME, AREA, AND THICKNESS WHEN REDRIED; AND LOSS IN WEIGHT BY LEACHING DURING THE SOAKING PERIOD

Paint	Weight loss: weathering: S_1/V_0	Density: Dry	Density: Swollen in water	Density: Redried	Initial thickness: T_0	Absorption of water: A/V_0	Swelling: In volume: ΔV_s	Swelling: In area: ΔQ_s	Swelling: In thickness: ΔT_s	Swelling efficiency: $\frac{\Delta V_s V_0}{A}$	Redried: Volume: ΔV_r	Redried: Area: ΔQ_r	Redried: Thickness: ΔT_r	Loss in weight soaking: S_2/V_0
	Percent				Mils	Percent	Percent	Percent	Percent	Percent	Percent	Percent	Percent	Percent
Antimony oxide	34.4	2.94	2.97	2.97	2.9	2.5	2.3	2.3	-0.7	92	-1.5	-0.8	-0.3	1.5
Lead titanate	12.8	3.23	3.24	3.24	5.9	3.8	.9	1.3	.2	24	-.4	-.7	+.5	.3
Basic carbonate white lead No. 1	21.7	3.11	3.11	3.16	3.9	7.4	3.9	2.2	1.0	53	-2.4	-1.1	-2.6	2.0
Basic carbonate white lead No. 2	21.0	3.26	3.06	3.11	2.8	9.9	8.7	.7	8.8	88	+2.3	-.7	+2.1	2.9
Basic sulfate white lead	36.3	3.37	3.27	3.38	3.6	7.5	4.9	2.0	3.6	65	-1.1	-.7	+.3	2.5
Basic silicate white lead	24.9	2.27	2.24	2.28	5.0	4.5	2.8	1.7	.8	62	-.8	-.5	-1.0	.6
Dibasic lead phosphite	11.1	3.27	3.21	3.27	3.1	4.4	3.3	1.4	1.3	75	-.8	-.2	-.3	2.7
Lead chromate	10.1	2.78	2.73	2.79	5.2	3.2	3.2	1.8	2.5	100	-.7	-1.3	-.4	.7
Basic lead chromate	16.3	3.12	2.99	3.14	3.2	7.2	7.5	4.2	6.6	104	-.7	-.9	-.9	.5
35 percent leaded zinc oxide	10.1	2.60	2.53	2.76	5.2	16.0	14.7	8.0	8.8	92	-5.7	+1.5	-6.1	.1
18 percent leaded zinc oxide (reactive)	16.1	2.80	2.53	2.80	2.9	20.0	18.5	10.3	6.8	93	-.3	+1.7	-2.0	.9
Zinc oxide No. 1	12.1	2.67	2.32	2.67	3.8	29.6	27.5	13.4	12.2	93	-.1	+4.1	-4.2	.6
Zinc oxide No. 2	11.7	2.63	2.30	2.61	3.8	28.2	26.0	7.4	26.0	92	0	+1.4	-.3	.8
Zinc oxide No. 3	19.6	2.71	2.17	2.65	3.9	25.5	27.3	11.6	21.3	107	+2.3	+3.3	+2.0	.7
Zinc oxide No. 4	40.8	2.89	2.44	2.82	3.1	32.0	30.8			96	+1.7			2.3
Zinc oxide (treated) No. 5	10.8	2.68	1.74	2.27	2.6	132	121	17.3	89.0	92	+10.8	+7.0	+3.9	5.4
Zinc sulfide	26.0	2.20	1.99	2.20	3.3	26.0	23.5	14.9	21.3	90	-2.0	+2.1	-2.1	4.6
Lithopone	27.2	2.27	2.19	2.36	3.1	16.1	15.3	7.2	8.7	95	-6.8	+.5	-6.7	6.1
Zinc chromate	9.2	1.94	1.88	1.95	4.4	8.5	8.5	4.3	7.7	100	-.9	-.6	-.7	1.1
Zinc dust	7.6	3.90	3.25	3.59	3.2	33.2	29.3	12.5	29.4	88	+7.7	+5.1	+2.5	3.7
Titanium dioxide (anatase) No. 1	55.1	2.36	2.36	2.34	2.7	9.6	3.2	2.2	2.2	33	-.8	-1.4	-.7	3.4
Titanium dioxide (anatase) No. 2	53.8	2.38	2.36	2.40	2.9	5.2	4.2	2.7	1.0	81	-1.9	-1.1	-.3	1.3
Titanium dioxide (rutile) No. 3	32.1	2.39	2.36	2.38	3.0	2.8	2.3	2.2	2.6	82	+.4	-.9	+.7	.4
Titanium dioxide (rutile) No. 4	19.0	2.28	2.24	2.30	3.5	4.6	4.3	4.3	3.5	93	-1.1	-1.4	-.9	.8
Titanium dioxide (rutile) No. 5	24.1	2.34	2.32	2.37	3.1	8.3	5.7	3.6	1.9	69	-1.8	-1.3	0	1.0
Titanium-Calcium	31.5	1.87	1.95	1.97	3.5	6.1	4.9	2.9	7.5		-8.8	-.7	-8.7	7.2
Ferric oxide red (manufactured) No. 1	22.4	2.52	2.22	2.52	2.9	26.2	25.5	12.6	10.3	97	-1.3	+.4	-1.4	2.6
Ferric oxide red (manufactured) No. 2	24.0	2.66	2.57	2.67	2.8	6.1	6.0	2.9	2.8	99	-.9	-.5	0	1.3
Ferric oxide red (natural) No. 3	16.1	2.36	2.30	2.37	4.0	4.6	4.9	1.7	4.3	107	-.7	-.9	-.5	.5
Venetian red	18.5	2.20	2.00	2.00	3.1	12.7	6.2	4.3	4.2	49	-2.1	-.8	-2.3	23.3
Ferric hydroxide yellow	19.9	2.21	2.17	2.25	3.0	6.0	6.0	2.9	3.4	100	-1.7	-1.4	0	1.1
Magnesium silicate No. 1		1.89	1.81	1.89	2.4	7.5	9.8	5.0	6.7	130	-2.1	-3.4	+.4	2.6
Magnesium silicate No. 2	19.0	1.77	1.72	1.78	3.5	7.6	7.5	2.1	6.0	99	-1.5	0	-1.7	2.1
Calcium carbonate No. 1	26.5	1.75	1.64	1.75	3.2	19.7	18.5	10.8	14.5	94	-4.2	-1.9	-4.0	7.9
Calcium carbonate No. 2	42.3	1.83	1.74	1.85	2.5	15.0	14.7	6.3	11.1	98	-3.6	-1.9	-3.6	5.4
Calcium carbonate No. 3	51.8	1.90	1.75	1.89	2.7	19.0	19.3	3.9	19.5	101	0	-1.9	+.4	.9
Calcium carbonate No. 4	44.3	1.77	1.68	1.79	2.7	15.2	14.9	6.6	4.4	98	-4.4	-.5	-4.0	6.1
Barium sulfate	61.4	2.71	2.67	2.69	2.7	7.8	4.0	3.2	4.1	51	+.2	-.1	0	1.2
Calcium sulfate	53.2	1.68	1.12	1.24	2.5	28.2	-3.9	-.6	-2.8		-35.7	-9.4	-29.2	88.5
Silica	51.5	1.78	1.81	1.78	2.7	8.7	3.7	1.7	2.2	43	-1.7	-.5	-1.5	2.3
Diatomaceous silica	51.8	1.28	1.40	1.18	3.3	48.5	22.8	1.6	22.7	47	+4.8	-.6	+4.8	4.9
Treated bentonite	45.8	1.41	1.37	1.43	2.6	13.8	14.1	5.5	5.5	102	-3.2	-.5	-2.6	2.2
Mica in bodied oil	34.1	1.40	1.39	1.47	1.9	19.5	19.9	1.1	17.3	102	-2.6	-.7	-2.6	1.9
Aluminum in bodied oil	20.1	1.30	1.29	1.32	2.1	9.7	9.4	1.8	8.0	97	-1.1	-.4	-1.4	.2

centimeters of films. Upon evaporation of the soaking water and drying, 39.6 grams of calcium sulfate crystals and 0.9 gram of organic matter were recovered. Likewise, calcium sulfate was found in the soaking water from the films containing titanium–calcium and Venetian red, for which the solubility losses were 9.9 and 15.9 grams per 100 cubic centimeters, respectively.

Films of zinc chromate paint lost 9.9 grams per 100 cubic centimeters to the soaking water and colored the water strongly with dissolved zinc chromate. But the water from the films of lead chromate paint, with a loss of 3.6 grams, remained colorless. Leaching from films of all paints containing ferric oxide were colorless and gave no test for soluble compounds of iron. The high loss in soaking of the film with ferric oxide No. 1 may be due to soluble ingredients in the pigment that were not identified.

Leachings from all paints containing zinc oxide, leaded zinc oxide, zinc sulfide, or zinc chromate contained substantial proportions of soluble zinc salts from which zinc sulfide could be readily precipitated by hydrogen sulfide. Presumably, zinc oxide and zinc sulfide reacted with organic acids from the linseed oil to form soluble zinc soaps.

Similarly, all calcium carbonate paint films yielded leachings from which the soluble calcium was precipitated as calcium oxalate in amounts that were proportional to the losses during soaking.

Weathered Films

The results obtained with films that were subjected to artificial weathering for 15 days before testing are reported in Table 2.

Weight Loss During Weathering: All paints lost weight during weathering. The losses ranged from 7.6 grams per 100 cubic centimeters of weathered film for zinc-dust paint to 61.4 grams for barium sulfate.

Zinc pigments generally exhibited low losses, from 7.6 to 27.2 grams per 100 cubic centimeters, except that zinc oxide No. 4, with very fine particle size, lost 40.8 grams. Zinc sulfide and lithopone lost more than any other zinc pigments except zinc oxide No. 4. Dibasic lead phosphite, lead titanate, the lead chromates, and leaded zinc oxides had low losses of the same order as zinc oxide Nos. 1, 2, 3, and 5, but the white leads lost somewhat more—about as much as zinc sulfide.

Losses by the titanium dioxide paints ranged from 19.0 to 55.1 grams per 100 cubic centimeters. The freely chalking anatase pigments lost more than 50 grams, much of which may have been in the form of chalk mechanically eroded from the surface of the films. Pure rutile titanium dioxide No. 3 lost 32.1 grams, and the zinc-containing, highly chalk-resistant titanium dioxide Nos. 4 and 5 lost only 19.0 and 24.1 grams, nearly all of which was probably in the form of water-soluble leachings. Titanium-calcium lost no more than titanium dioxide No. 3 despite its content of calcium sulfate.

The iron oxide pigments, including Venetian red, aluminum, and magnesium silicate, exhibited losses of about the same order of magnitude as the lead and zinc pigments. But barium sulfate, calcium sulfate, silica, mica, and treated bentonite gave high losses. Losses by calcium carbonates varied from 26.5 to 51.8 grams per 100 cubic centimeters.

It is not yet possible to explain satisfactorily the variation in weathering losses by paints of differing pigmentation. Probably several factors are involved. It has already been shown (4) that much of the loss occurs early in the weather exposure before chalking sets in.

Leaching of water-soluble ingredients presumably accounts for the first portion of the loss on weathering. It is, in turn, regulated in amount by the effect of the pigments on the disruptive oxidation of the oil vehicle and by the solubility of any soaps formed by reaction between chemically active pigments and acid decomposition products of the oil vehicle. Later on there may be additional mechanical loss by chalking from the surface if a condition of free chalking sets in.

Density Changes: Weathering increased the density of all paint films except those of paints made with diatomaceous silica, for which the density dropped from 1.31 before weathering to 1.28 afterward. The anomalous behavior of the diatomaceous silica paint may be connected with the porosity of the film due to the porous nature of the pigment itself.

The swelling efficiency of the 10-day old films was 87 per cent and that of the weathered films 47 per cent. Perhaps the increased porosity on weathering was sufficient to diminish the density. For all other paints the increase in density during weathering was in accord with the contraction in volume normally expected in linseed-oil paints (9).

The density of the weathered films usually decreased when they were swollen in water, just as was always the case with unweathered films. But with weathered films there were seven exceptions to the general rule. Films of the paints with basic carbonate white lead No. 1 and titanium dioxide No. 1 were not changed measurably in density. Films of antimony oxide, lead titanate, and silica paints increased slightly in density when swollen in water. These were all films of low absorption of water, low volumetric swelling, and low swelling efficiency after they had been weathered.

Where most of the water absorbed is held in pores and little water enters the vehicle to cause swelling, the density when wet should exceed the density when dry. The film of diatomaceous silica paint, which was decidedly porous even before weathering, showed this effect even though it absorbed a relatively large amount of swelling water in addition to the free water in pores.

The increased density of the films of titanium-calcium paint after soaking corresponded to an actual loss in volume of 4.9 per cent during the soaking period. This loss was caused by leaching of the calcium sulfate in the pigment, which left a higher proportion of the heavier titanium dioxide in the leached film. This effect did not appear in the unweathered films because it was overbalanced by the much greater absorption of swelling water.

On redrying after soaking, the density usually returned to the density before soaking or to a slightly higher density unless the film remained swollen in volume, as with basic carbonate white lead No. 2, zinc oxide Nos. 3, 4, and 5, zinc dust, titanium dioxide No. 3, barium sulfate, and diatomaceous silica, or unless there was a large loss of soluble ingredients during the soaking period as with calcium sulfate and Venetian red.

Absorption of Water: Weathered films of all but five of the paints absorbed less water than the unweathered films. The five exceptions can be explained in part on the basis of difference in film thickness because the weathered films were all thinner than the unweathered films.

With the diatomaceous silica paint, and perhaps to a less extent with the paints made with basic carbonate white lead No. 2 and treated zinc oxide No. 5, the increased porosity of the weathered films was a contributing factor by permitting the weathered films to take up more free water in pores. The other two exceptions were the mica and the aluminum paints, both of which contained much less pigment than the other paints, and in both of which the pigments concentrated largely at the surface of the film, leaving nearly a pure vehicle in the underlying parts of the film.

A previous paper (5) reported that bodied linseed oil absorbs more water after weathering than before. Thus, the mica and aluminum paints seem to act much like unpigmented oil. If so, the smaller increase in absorption by aluminum than by mica paint is due to the high opacity of aluminum and the transparency of mica to visible and ultraviolet light.

Weathering reduced the absorption of water by films of paint containing zinc oxides and leaded zinc oxides from the level of 75 to 110 per cent to the order of 16 to 32 per cent. But the zinc oxide treated with vinyl silane absorbed even more water after than before weathering.

Zinc sulfide, lithopone, and zinc-dust paints still absorbed from 16 to 33 per cent of water after the films were weathered. Films containing titanium dioxides after weathering fell in the low-absorption class with 2.8 to 9.6 per cent absorption. Weathered iron oxide films, with the exception of ferric oxide No. 1, and magnesium silicate films also were low in absorption.

Swelling: Weathering reduced volumetic swelling as much or more than it did the absorption of water. Films for which the swelling efficiency remained 96 per cent or higher were those made with the lead chromates, zinc oxide Nos. 3 and 4 (but not Nos. 1, 2, or 5), zinc chromate, ferric oxide Nos. 1, 2, and 3, ferric hydroxide, magnesium silicate, calcium carbonate Nos. 2, 3, and 4 (but not No. 1), treated bentonite, mica, and aluminum. For all other films the swelling efficiency after weathering was less than 96 per cent, indicating the development of porosity.

Films for which the swelling efficiency after weathering became less than 80 per cent were: lead titanate, all white leads except basic carbonate No. 2, dibasic lead phosphite, titanium dioxide Nos. 1 and 5, Venetian red, barium sulfate, silica, and diatomaceous silica.

Swelling of weathered films in area was less than the swelling in volume except for films containing antimony oxide, lead titanate, and titanium dioxide No. 4, for which the swelling was small enough for experimental error to account for the anomaly; and for calcium sulfate and titanium-calcium, for which the leaching of calcium sulfate caused abnormalities.

Weathered films, in contrast to the unweathered films, showed a strong tendency to swell more in thickness than in area. For 22 of the 40 weathered films for which the data are available, the swelling in thickness exceeded the swelling in area, whereas the proportion for unweathered films was 8 of 44. The ratio of swelling in area to swelling in thickness ranged from 0.02 to 2.3 for weathered films compared with 0.4 to 3.7 for unweathered films, if 1 or 2 films with swelling too small for accurate measurement are excluded from each set.

Evidently the denser, harder, more brittle films produced by weathering find it easier to change in thickness than in area. Calcium sulfate and titanium-calcium paint films shrank in thickness during the soaking period, but they lost much of their calcium sulfate by leaching.

Shrinking on Redrying: On redrying after soaking, most weathered films shrank to a smaller volume than they had before soaking, but such residual shrinkage was usually less for the weathered than for the unweathered films. The decrease in residual shrinkage after weathering was due largely to a concomitant decrease in the leaching loss during soaking.

Films of lithopone, Venetian red, and calcium sulfate paint shrank more and lost more by leaching after weathering than before. But films of titanium-

calcium, calcium carbonate No. 1, and treated bentonite paint shrank slightly more despite slightly lower leaching loss after than before weathering; and weathered films of 35 per cent leaded zinc oxide paint shrank much more despite much lower leaching loss than the unweathered films.

The weathered films showed less tendency to shrink more readily in thickness than in area than was the case for unweathered films. Thus, only 10 weathered films, compared with 33 unweathered films, retained larger area after redrying than before soaking; and 10 weathered films, compared with only 1 unweathered film, were thicker after redrying than before soaking.

Embrittlement by weathering apparently renders the films less capable of accomplishing their volumetric shrinkage more by change in thickness than by change in area. No doubt this property is closely connected with the fact that paints seldom develop checks or cracks from their own internal stresses until they have become embrittled by weathering.

Loss in Weight While Soaking: Weathered films of all but eight paints lost less in weight during soaking than the corresponding unweathered films. The unweathered films probably contain water-soluble decomposition products of linseed oil that are leached out during weathering. In addition, it may be that weathered linoxyn is less subject to hydrolysis during soaking than is unweathered linoxyn.

The eight paints that lost more in weight during soaking after than before they were weathered were: the paints made with dibasic lead phosphite, zinc sulfide, lithopone, zinc dust, Venetian red, calcium sulfate, silica, The leaching losses by films of dibasic lead phosphite paint and the silica paint were so small both before and after weathering that the differences may be of no significance.

The losses by the films of zinc-dust paint were slightly larger but the difference between the weathered and unweathered films was small enough to be of doubtful significance. The increase in porosity of the diatomaceous silica paint after weathering may have allowed the soaking water to have had longer access to the inner portions of the films than before weathering. The other anomalous paints are ones for which the leachings include much soluble material derived from the pigment, and for which the increased porosity on weathering may well render the pigment more accessible to the soaking water.

The calcium sulfate paint and the Venetian red paint yielded much calcium sulfate to the soaking water. The titanium-calcium paint, which also contained calcium sulfate, had high leaching loss after weathering, even though the loss was slightly less than before weathering.

In the films of zinc sulfide and lithopone paints, the soluble zinc salts probably are formed by reaction between zinc sulfide and organic acids from decomposition of the oil. Apparently such reactions go on in weathered films more readily with zinc sulfide than with zinc oxide, either because zinc sulfide reacts with weaker acids than zinc oxide does or because the pigments have different effects on the formation of the organic acids from linoxyn.

Conclusions

1. Linseed-oil paints containing pigments increased in density when the liquid paint hardened to a dried coating. But the increase in density was less than that calculated on the assumption that the oil in the paints gains as much in weight and density as unpigmented linseed oil does in the same length of time (10 days). The discrepancy between calculated and observed density differed for different pigments and seemed to be related to the effect of the pigments on the absorption of oxygen and loss of volatile material by linseed oil as reported in the literature. There was a further increase in density of films during artificial weathering except for diatomaceous silica paint, which contained a structurally porous pigment, and which may have increased in pore volume during weathering.

2. Unweathered films always decreased in density as they absorbed water and, on redrying, returned to a density at least as high as that before soaking, unless the soaking water leached out soluble material derived from the pigment to cause a lowering of the density. Most weathered films behave similarly, but if weathering made the film sufficiently porous to hold enough free water, which caused no swelling, the density when soaked sometimes exceeded the density when dry.

3. All paints lost in weight during weathering, but the weight loss varied widely with different pigments. Part of the loss occurred early in the weathering period and was probably water-soluble material extracted by rain, the amount of which may be governed by the effect of pigments on the disruptive oxidation of linseed oil. Later in the weathering period, paints that chalked freely lost substance by mechanical erosion from the surface.

4. Some pigments reduced the absorption of water by free films below the absorptiveness of unpigmented linseed oil. In this class were the white leads and other lead pigments, antimony oxide, barium sulfate, silica, mica, and aluminum. Little effect on absorption was exerted by zinc-free titanium dioxides, some iron oxides, and calcium carbonate of coarse particle size.

Zinc oxides, leaded zinc oxides, zinc chromate, one iron oxide, Venetian red, and most calcium carbonates made paint films highly absorptive. Other pigments such as zinc sulfide, lithopone, zinc-treated titanium dioxides, and magnesium silicates made paint films of greater absorptiveness than unpigmented linseed oil but less than zinc oxide paints.

Efforts to relate the effect of pigments on the absorption of water to such surface properties as the relative wetting by water and organic liquids or the interfacial tension between pigments and liquids were fruitless. But there does seem to be a relation to the effect of pigments on the absorption of oxygen and evolution of volatile substances from linseed oil while drying.

5. Weathering reduced the absorption of water by paint films materially, unless it greatly increased the porosity of the films or unless the pigments were of the leafing type (mica and aluminum), so that most of the underlying portions of the oil film contained little or no pigment and acted like unpigmented linseed oil.

6. The volumetric swelling of unweathered free films was nearly equal to the absorption of water; that is, the swelling efficiency was close to 100 per cent, unless the films contained pigments from which the water extracted much soluble matter.

Weathering diminished the volumetric swelling proportionately to the absorption, leaving the swelling efficiency near 100 per cent, for films of paint made with the lead chromates, zinc chromate, some zinc oxides, some iron oxides, ferric hydroxide, magnesium silicate, some calcium carbonates, treated bentonite, mica, and aluminum. Films containing any other pigments decreased in swelling efficiency and presumably became porous on weathering.

7. Unweathered films always swelled less in area than in volume and usually swelled still less in thickness. Weathered films, in contrast, tended strongly to swell more in thickness than in area.

8. Films of paints made with acicular pigments swelled more, sometimes 4 to 5 times as much, across the grain than along the grain of the paint. The grain is determined by the direction of last flow of the liquid paint before the coating hardens.

9. Unweathered films, on redrying after soaking, shrank to a volume slightly smaller than that before soaking unless the swelling efficiency indicated that the film was somewhat porous. The residual shrinkage was due chiefly to extraction of soluble substances by the soaking water. Often the

area remained enlarged after drying, but the thickness was always diminished. Thus, unweathered films seem to shrink in thickness more readily than they do in area.

10. For weathered films redried after soaking, the residual shrinkage in volume was usually less, but so was the loss of soluble matter, than that of unweathered films. Weathered films proved much less likely to shrink proportionately more in thickness than in area than was the case for unweathered films.

11. Films of all paints lost weight from extraction of soluble matter when soaked in water. When the pigments were insoluble and nonreactive, the material dissolved consisted entirely of organic matter derived from the linseed-oil vehicle, much of which could be recovered by evaporating the leaching water to dryness.

When the pigments contained water-soluble ingredients or formed soluble salts by reaction with organic acids from decomposition of the oil, the losses were larger and the leachings contained the inorganic constituents from the pigments in addition to organic matter from the oil. Weathering reduced the amount of soluble organic matter leached from the films, but it sometimes increased the amount of inorganic extract.

References

1. Bartell, F. E., and Hershberger, A. 1930. Liquid absorption by pigments of different types of organic liquids. I. Relation of liquid absorption with a series of organic liquids to interfacial tension of these liquids against water. Industrial & Engineering Chemistry 22:1304–9.
2. _____, and Bartell, L. S. 1934. Quantitative correlation of interfacial free surface energies. Journal of the American Chemical Society 56:2205–10.
3. Browne, F. L. 1935. The effect of change from linoxyn gel to xerogel on the behavior of paint. Colloid Symposium Monograph 11:211–22.
4. _____. 1953. The absorption of water, swelling, and solubility of free films of paint. Journal of the Forest Products Research Society 3 (No. 5):108–24.
5. _____. Swelling of paint films in water. II. Absorption and volumetric swelling of bound and free films before and after weathering. Journal of the Forest Products Research Society.
6. _____. Swelling of paint films in water. III. Absorption and volumetric swelling of bound and free films from air of different relative humidities. Forest Products Journal V (1):92.
7. _____. Swelling of paint films in water. IV. Effect of thickness of film and pigment volume of paint. Forest Products Journal V (2).
8. Carrick, L. L., and Permoda, A. J. 1951. Shrinkage of some organic film forming materials during aging. Official Digest, Federation of Paint and Varnish Production Clubs, No. 322: 692–700.
9. Clark, G. L., and Tschentke, H. L. 1929. Physico-chemical studies on the mechanism of the drying of linseed oil. I. Changes in density of films. Industrial & Engineering Chemistry 21:621–7.
10. Dunn, E. J., Jr. 1954. Moisture resistance of paint films. Paint Industry Magazine 69 (No. 9):13–16, 20–2.
11. Gardner, H. A. 1926. The color number of dry pigments and experiments on the selective absorption of various pigments and liquids. American Paint and Varnish Manufacturers' Association, Scientific Section Circular 295.
12. _____. 1932. Notes on colloidal phenomena in paint and varnish products. Colloid Chemistry by Jerome Alexander, Vol. IV, 477–94.
13. Long, J. S., Rheineck, A. E., and Ball, G. L. 1933. Studies in the drying oils. XVII. Influence of several factors on the mechanism of drying of oil films. Industrial & Engineering Chemistry 25:1086–91.
14. MacGregor, J. R. 1952. The unexplored field of exterior paint. Official Digest, Paint and Varnish Production Clubs No. 335:869–80.
15. Rhodes, F. H., and Van Wirt, A. E. 1923. Effect of various pigments upon the rate of oxidation of linseed oil. Industrial & Engineering Chemistry 15:1135–40.
16. _____, Burr, C. R., and Webster, P. A. 1924. Effect of iron oxide pigments on rate of oxidation of linseed oils. Industrial & Engineering Chemistry 16:960–2.

Losses Incurred in Drying and Dressing Lumber in the Southern Interior of British Columbia[1]

C. F. McBRIDE

Vancouver Laboratory, Forest Products Laboratories of Canada, Division of the Forestry Branch, Department of Northern Affairs and National Resources, Canada

Study was made to determine extent of losses in volume and value during drying and planing lumber at different mills. Losses in air-drying and kiln-drying are compared.

EXPANSION IN THE SAWMILL industry in the southern interior of British Columbia has been rapid in the last decade. In 1943 there were 225 active sawmills with an 8-hour total capacity of 2,416 M ft.b.m. By the end of 1953, many additional small mills had become established, bringing the total to 999 sawmills with an estimated 8-hour total capacity of 7,120 M ft.b.m. In this period, the total cut increased almost three-fold to 905,279,032 board feet log scale per annum.[2]

During the post-war period of high prices and heavy demand, the main effort of the mills was towards increasing production. Then came a period of lower selling prices when the emphasis was on efficiency and reduction in wood waste. It was realized that, between the green chain and the boxcar when lumber is dried and planed, volume and value losses must be incurred, but it was not known whether or not these losses were excessive.

A study was therefore undertaken by the Vancouver Laboratory of the Forest Products Laboratories of Canada to determine the extent of these losses at different mills in the southern interior of British Columbia. Mills selected were considered to be representative of good to average mill practice for the region.

The study included both air-dried and kiln-dried lumber. However, since measurements of kiln-dried lumber have

[1] Presented at a meeting of the Pacific Northwest Section, FPRS, Oct. 25, 1954, in Corvallis, Oregon.

[2] Annual Reports of the British Columbia Forest Service, 1943 and 1953, Victoria, B. C.

The Author: C. F. McBride received B.A.Sc. degree in forest engineering from U. of British Columbia in 1935. He served in various capacities with the British Columbia Forest Service from 1935–45, when he joined Vancouver Laboratory as sawmill specialist.

not been completely analyzed, this paper has reference to the whole air-dried sample. For purposes of comparison, part of the kiln-dried sample has been added.

Production

There are a number of commercial species, chiefly conifers, in the southern interior, and in 1953 the percentage distribution of this cut was as follows:

Species	Per cent
Douglas-fir	52
Spruce	15
Western larch	11
Western red cedar	7
Ponderosa pine	5
Western white pine	4
Western hemlock	3
Lodgepole pine	2
Balsam	1
	100

The character of the timber in this area is such that a heavy percentage of the better grades of common and only a small percentage of the clear grades of lumber are produced. In certain localities the fir is shakey and yields a high percentage of No. 3 and No. 4 Common.

Study Methods

The air-dry lumber sample consisted of a total of 55,269 ft.b.m. in 25 parcels distributed as follows: 7 Douglas-fir, 5 ponderosa pine, 10 spruce, and 3 white pine.

This lumber was either selected at random as it came from the green chain in accordance with individual mill sorting practice, or it was specially marked for later measurement and observation. All controversial pieces were eliminated.

Each parcel was marked and stacked for air drying for approximately 70 days in the summer. After drying and dressing, the lumber was graded and tallied, and any piece that had changed grade was noted and the rough green grade was ascertained. Douglas-fir and larch were graded according to the West Coast Lumbermen's Association lumber grading rules—List No. 14; while the spruce, ponderosa pine, and white pine were all graded under Western Pine Association Rules.

Measurements of width and thickness were taken on selected pieces when green and when dry.

The kiln-dry lumber sample analyzed to date consisted of 67,847 ft. b.m. in 15 parcels distributed as follows: 4 Douglas-fir, 3 ponderosa pine, 3 spruce, and 5 white pine.

This lumber was selected at random by carrier loads as it came from the kiln. The boards were planed and the dry dressed grade tallied. Any piece that had changed grade was noted and the rough green grade was determined.

Loss in value was calculated at prices revailing in March, 1954.

Table 1.—LOSS IN VOLUME BY SPECIES AND CAUSES

	Percentage of Total Loss in Volume									
	All Species		Douglas Fir		Spruce		Ponderosa Pine		White Pine	
	Air-dried	Kiln-dried	Air-dried	Kiln-dried	Air-dried	Kiln-dried	Air-dried	Kiln-dried	Air-dried	Kiln-dried
Natural trim...	27	52	6	60	24	47	45	53	15	51
Seasoning trim.	29	24	46	15	37	37	9	15	10	20
Manufacturing trim.....	23	22	48	25	19	14	24	30	18	26
Manufacturing thinness.....	21	2	--	--	20	2	22	2	57	3
Total:	100	100	100	100	100	100	100	100	100	100
Total green volume, ft.b.m.	55269	67847	13855	11333	23612	16705	12717	14474	5085	25323
Loss of volume, ft.b.m.....	1401	2274	161	354	672	697	461	315	107	908
Percentage of green volume...	2.5	3.3	1.2	3.1	2.8	4.2	3.6	2.2	2.1	3.6
Percentage loss of volume other than natural trims..	1.9	1.7	1.1	1.3	2.2	2.2	2.0	1.0	1.8	1.8

Seasoning Methods

The usual air-drying practice was to strip with three-quarter to one-inch stickers in carrier loads, and then pile the loads two or three high with a lift-fork truck. One mill did not sticker the fir loads. Only one mill box-piled the lumber by hand.

The kilns were all of the cross-circulation, steam-heated charge type. Kiln trucks were loaded with four carrier loads—two abreast and two high—except in one mill where the loads were built up by hand on the kiln trucks. Two kilns were the side-opening type where loading is done directly with lift-fork trucks. Three-quarter to one-inch stickers were used throughout.

The parcels studied showed the following range of average final moisture contents:

	Air-dried	Kiln-dried
Douglas-fir	12%–16%	16%–25%
Ponderosa pine	9%–16%	9%–16%
White pine	13%–14%	13%–14%
Spruce	8%–10%	7%–12%

The bulk-piled, air-dried material averaged 12 to 15 per cent moisture content, but the range of individual moisture readings was 10 to 22 per cent, which was considerably wider than that applying to the stickered packages.

Lift-fork trucks have facilitated lumber handling in the mill yards, but when operated carelessly they have been the cause of considerable degrade. One type of damage is broken edges from the forks and the most frequent is the degrade from warped boards on the bottom and top layers due to improperly placed spacer blocks.

The grades of lumber dried are related to specific mill practice. Mills with large production segregate clears and these are dried regardless of species. Most mills do not dry fir and larch commons. All clear and common grades of white pine, ponderosa pine, and spruce boards are dried.

Loss in Board Foot Volume

In the air-dried sample the total loss in board footage amounted to 1401 ft.b.m., or 2.5 per cent of the total green volume examined. This loss was in trims and excessive thinness. The trims were divided according to causes into three broad classes—(1) natural, (2) seasoning, and (3) manufacturing. The thinness loss is a loss in board feet because the pieces, being too thin to make any grade without remanufacture, were tallied as thinner pieces (i.e., 1-inch boards tallied as $\frac{1}{2}$-inch) as if they had been machined again.

The natural trims were those which removed natural defects, such as wane, shake, rot, and knots not trimmed in the mill. Natural trims cannot really be classified as wasted wood volume. Such trims improve the grade of the piece. The amount of natural trims varied considerably according to mill practice. Some manufacturers prefer to do most of their trimming in the green, and only trim in the planing mill to remove seasoning and manufacturing defects. However, the usual practice is to leave more trimming to be done behind the planer in the expectation that wane and other defects will dress out for a higher volume recovery.

The natural trims are included for the purpose of correlating nominal green volume at the mill with finished volume and to indicate how much kiln space and handling is involved with material which has no value. These natural trims amounted to 0.7 per cent of the green volume of the air-dried lumber and 1.7 per cent of the kiln-dried lumber.

The trims for seasoning defects were those directly related to the drying of the lumber. Checked ends were the most common defect, while others encountered were season checks, loosened knots, knot holes, and warp. These trims from the air-dried lumber amounted to 0.7 per cent of the green

Table 2.—LOSS IN VALUE BY CAUSES AS PERCENTAGE OF TOTAL LOSS IN VALUE

	Percentage of Total Loss in Value									
	All species		Douglas fir		Spruce		Ponderosa Pine		White Pine	
	Air-dry	Kiln-dry	Air-dry	Kiln-dry	Air-dry	Kiln-dry	Air-dry	Kiln-dry	Air-dry	Kiln-dry
Seasoning degrade (1)	49	19	43	11	50	34	40	26	57	5
Seasoning trim	11	22	14	30	13	25	6	11	4	23
Total seasoning loss	60	41	57	41	63	59	46	37	61	28
Manufacturing degrade (2)	18	36	37	5	19	30	19	41	5	42
Manufacturing trim	8	21	6	54	9	10	20	21	8	27
Manufacturing thinness	14	2	--	--	9	1	15	1	26	3
Total manufacturing loss	40	59	43	59	37	41	54	63	39	72
TOTAL:	100	100	100	100	100	100	100	100	100	100
Percentage of Total Value	6.9	3.8	5.0	1.6	7.9	6.7	5.5	3.4	6.8	3.4
Loss in Value per M ft. b.m.	$6.40	$3.60	$3.30	$1.00	$8.10	$5.30	$4.00	$2.60	$10.60	$4.40
Average Lumber Value per M ft.b.m.	$92	$95	$66	$66	$101	$79	$72	$78	$157	$128

(1) See Table III for breakdown by causes.
(2) See Table IV for breakdown by causes.

volume and from the kiln-dried lumber amounted to 0.8 per cent.

Trims to eliminate manufacturing defects were made both in the planing mill and the sawmill. These included thin ends, saw cuts, broken ends and edges, machine snipe, and scant width. They amounted to 0.6 per cent of the green volume of the air-dry sample and to 0.7 per cent of the kiln-dry sample.

Loss in volume due to excessive thinness amounted to 0.5 per cent of the green volume of the air-dry lumber and was negligible for the kiln-dry sample.

The volume losses by species and causes are shown in Table I. Manufacturing losses include trims and volume loss due to excessive thinness.

For air-seasoned lumber the total loss in volume was 2.5 per cent, or 1.9 per cent when the natural trims are ignored. The latter figure applies closely for spruce, ponderosa pine, and white pine. For Douglas-fir, however, the loss was only 1.1 per cent.

For kiln-dried material the total loss in volume averaged 3.3 per cent, or 1.7 per cent when natural trims are eliminated.

The samples showed that the loss in volume for Douglas-fir, spruce, and white pine was very similar for the two methods of drying, but for ponderosa pine the loss in the kiln-dried sample was only 1 per cent, or one-half the loss incurred in air-drying.

Loss in Value

To determine the loss in value between green and finished lumber, the green lumber was valued at the finished dry price, as if no loss in volume or degrade had occurred.

Loss of value occurred through loss in volume and by degrade. The loss in volume due to seasoning trim, manufacturing trim, and excessive thinness was evaluated, but natural trims were considered to have no value. In a very few cases the grade of a piece was raised when trims were made for manufacturing or seasoning defects. This increase in value was accounted for in the pricing, but the increase in value was so insignificant that it is not presented as a separate item. The figures for loss in value shown are those for net loss in value.

The degrade of lumber develops either in the process of seasoning or in the process of manufacturing. The seasoning degrade observed in this study was caused by roller checks, season checks, loosened knots, and warp; while the manufacturing degrade was caused by thinness and skips in dressing, scant width, machine snipe, broken edges and ends, chipped knots, and carrier damage.

The percentage losses in value are summarized in Table II by species and drying methods under the broad causes: (1) seasoning, which has been subdivided into loss by degrade and by trim, (2) manufacturing, which has been divided into loss by degrade, trim, and thinness.

The average loss in value for the air-dried lumber was 6.9 per cent, or $6.40 per M ft.b.m. of which 60 per cent was from seasoning defects.

The percentage loss in value by causes in the air-dried lumber was quite consistent, except for ponderosa pine, which showed a lower seasoning loss than other species studied.

The loss in value per M ft.b.m. varied more than the percentage loss indicates because of the wide range in average value per M ft.b.m. by species. The lower loss in the Douglas-fir was partly due to fir being 2-inch stock while the other species were mostly boards.

For the kiln-dried lumber, the average loss in value was 3.8 per cent or $3.60 per M ft.b.m. of which 41 per cent was from seasoning defects. The rest were manufacturing defects.

Comparing the different species shows a low loss of 1.6 per cent for fir, while losses for ponderosa and white pine were 3.4 per cent, and for spruce the loss was highest with 6.7 per cent.

A comparison between kiln-dried and air-dried losses shows that the kiln-dried lumber had a much lower loss from seasoning degrade and a higher loss from seasoning trim than the air-dried lumber. Seasoning trim was made mainly to eliminate end-checks. This indicates that the kiln schedules could be modified to eliminate some of the end-checking. The value of manufacturing losses was similar for both types of drying.

The figures in Table III show the percentage of the value of seasoning degrade attributable to each cause of degrade. The significance of these figures is best assessed when they are related to the total value of the seasoning degrade shown in Table II. Season check and cup split were the most serious defects. Warp caused by poor piling accounted for a considerable loss especially in the ponderosa pine. The loss from warp in kiln-dried fir is a high percentage, but the value lost is not significant as the total seasoning loss is very small.

Table IV shows the percentage based on value of the manufacturing degrade by causes. Thinness and scant width caused the greatest loss. Chipped knots

Table 3.—CAUSES OF SEASONING DEGRADE SHOWN AS PERCENTAGE OF VALUE OF SEASONING DEGRADE

Causes	Douglas fir		Spruce		Ponderosa Pine		White Pine	
	Air-dry	Kiln-dry	Air-dry	Kiln-dry	Air-dry	Kiln-dry	Air-dry	Kiln-dry
eason check	79	20	31	15	24	40	100	35
ip split	15	-	42	85	15	23	-	65
ost holes	3	-	14	-	24	-	-	-
ose knots	-	-	3	-	-	-	-	-
ecked knots	1	-	1	-	19	-	-	-
rp	2	80	9	-	18	37	-	-
o t a l:	100	100	100	100	100	100	100	100

Table 4.—MANUFACTURING DEGRADE SHOWING PERCENTAGE BY CAUSES

Causes	Douglas Fir		Spruce		Ponderosa Pine		White Pine	
	Air-dry	Kiln-dry	Air-dry	Kiln-dry	Air-dry	Kiln-dry	Air-dry	Kiln-dry
Thinness	-	28	52	77	67	71	-	79
Scant width	96	-	10	12	23	26	-	17
Chipped knots	2	-	14	7	5	-	-	-
Machine damage	2	72	4	2	5	-	26	4
Transportation damage	-	-	20	2	-	3	74	-
T o t a l:	100	100	100	100	100	100	100	100

in the spruce were responsible for similar loss in both air-dry and kiln-dry lumber. Damage by transportation equipment, such as carrier and lift trucks, was high in the spruce and the air-dried white pine.

Planer shavings are one of the main sources of wood loss between the standing tree and the finished product.

In this study the volume of shavings produced from surfacing air-dry lumber varied from 21 to 31 per cent of the rough green lumber volume. The actual amount of shavings produced varied from 0.26 to 0.49 unit[3] per thousand with an average of 0.41.

When ideal conditions are assumed so that the lumber is cut to a size which allows only for shrinkage and 1/8 inch and 3/16 inch respectively for dressing in thickness and width, the amount of shavings produced from dressing 2" x 6" lumber would be 0.1 unit/M ft.b.m. Allowing 3/16 inch in thickness and 1/4 inch in width for sawing tolerance, the maximum volume of shavings would be 0.27 unit/M ft.b.m. Thus the average would be 0.19 unit/M.

Using these figures as a basis for calculations, the volumes of shavings produced were in the range of 26 per cent to 158 per cent too high.

Losses from Poor Sawing

Accuracy of sawing has not been emphasized enough in many small mills. In order to insure that boards are of sufficient size to dress out, there is a tendency to cut oversize to allow for sawing variation.

In this study, the pieces were divided into three classes: oversize, on-size, and undersize. The basis used was the finished size plus allowances for shrinkage, sawing variation and dressing.

The shrinkage was calculated to 12½ per cent moisture content. For thickness, the allowance for sawing variation was 3/16 inch and for dressing 1/8 inch. For widths, the allowance for sawing variation was 1/4 inch and for dressing 3/16 inch.

The fir dimension stock averaged:—

	Undersize	On-size	Oversize
Thickness	2%	58%	40%
Width	13%	56%	31%

The excess volume from oversize cutting amounted to 4.0 per cent of the total wood volume in the fir parcels.

The spruce boards averaged:—

	Undersize	On-size	Oversize
Thickness	25%	59%	16%
Width	----	45%	55%

The loss from cutting oversize was 2 per cent of the total volume in the spruce parcels.

The tendency in spruce operations was to cut light on thickness and heavy on the width. The spruce finished up with less thin boards than would be indicated by the undersize percentage, because spruce cuts more smoothly than fir and it is possible to get clean dressing with less than 1/8 inch if the sawn surfaces are smooth.

The loss from cutting oversize was 2 per cent of the total volume in the ponderosa and white pine parcels.

Boards of all species too thin to make a No. 4 Common were considered as 1/2-inch boards, and the resulting loss was $0.70/M ft.b.m., or 0.5 per cent of the volume.

In the air-dry study the loss in value due to poor sawing, which includes loss in volume due to excessive thinness, trims for thin ends and scant widths, and degrade due to thinness, amounted to $1.67 per M ft.b.m.

Summary

The average wood volume made into planer shavings was 26 per cent of the rough green volume.

The average loss in volume due to cutting 1-inch material oversize was 2.0 per cent. For 2-inch material it was 4.0 per cent.

The average loss in volume from the trimming of seasoning and manufacturing defects and from excessive thinness from all species was 1.9 per cent for the air-dried lumber and 1.7 per cent for the kiln-dried lumber.

The average loss in value from air-drying was 4.1 per cent and from kiln-drying was 1.6 per cent. The average loss of value from poor manufacturing for the air-dried lumber was 2.8 per cent and for the kiln-dried lumber 2.2 per cent.

[3] 1 unit = 200 cu. ft. of loose material. 1 solid cu. ft. = 3 cu. ft. of loose shavings.

A New Direct Heat Exchanger for Kiln Drying Lumber[1]

PETER FIELD

Director of Research, Ivory Pine Co., Dinuba, Calif.

Describes construction and operation of a specially designed method of heating dry kilns. Kilns with direct heat exchangers were found to be efficient, safe, and low in operating costs.

WITH A NUMBER of well designed and engineered dry kilns on the market, what reason would a medium sized lumber operation have in engineering and building a kiln with many new and untried features?

In the Spring of 1952 the Ivory Pine Company did just that for reasons that follow. This plant is completely electric, hydraulic, and air operated. It has no steam facilities. When the need came for installing a dry kiln, it did not seem economical to buy a boiler just for this purpose. It appeared a waste of effort to burn fuel in a water boiler, produce steam, and extract heat units from it to dry lumber.

The technically trained personnel of the plant were divided into research teams of two men each. One team studied the newest insulation and construction methods. Another went into the latest developments in automatic instruments. A third had the assignment of an improved type oil burner and a new direct heat exchanger. After each field trip, conferences were held at which time the best findings of each group were reported.

Outside experts in government and commercial service were called in at the conferences to criticize and advise as each step was developed and decided upon. Out of this, in three weeks time, evolved the kiln which was built.

Very early in the considerations, it was decided to use a direct source of heat. This narrowed the choice to one of two possibilities.

1. The direct products of combustion.
2. Heat exchanging within the kiln.

Theoretically, the direct use of the products of combustion in a kiln gives as near 100 per cent efficiency as is possible. The hot gases are injected into the air stream, through a duct, directly into the kiln chamber. The circulating fan arrangement may be the same as in conventional kilns, either under the floor, or on top running the length of the chamber.

This method, however, has some very serious drawbacks. One is the great fire danger, another is the possibility of improper combustion occurring inside the kiln and the resultant covering of the lumber with a coat of soot. So this method of heating was discarded.

This left the heat exchanger located in the air stream. Kiln manufacturing companies were asked to design such a kiln, using an exchanger as a source of heat. At that time, however, not one of the companies appeared to show any interest.

Source of Heat

A heat exchanger as applied to a dry kiln is simply a large radiator from which the circulating air in the kiln absorbs the available heat units. In this case, it is a series of steel pipes 10 feet long, with wind boxes at either end, through which the heat makes four passes before being exhausted to the atmosphere. Initial combustion occurs in a fire-brick lined 16-inch tube, followed by passes through a series of smaller pipes.

As with a boiler, efficiency is designated by the temperature of the exhaust gases. Tests show this to be under 200° F., or an efficiency of 85 per cent. Many steam boilers, even modern automatic ones, run as low as 60 per cent.

The source of heat is provided by a rotary, atomizing Johnson oil burner. It is designed so that it will consume oil at its maximum capacity of 15 gallons an hour or modulate to as low as 2 gallons an hour when it only has to maintain the designated temperature. For this purpose, the Johnson Company introduced a newly designed metering pump on their burner.

Construction of Building

Not only must a kiln be heated, but the heat units must be preserved by the type of construction. In the walls, what was then a rather new method of concrete construction, known as "Tilt Up Concrete Panel Construction", was used. Full panels, some as large as 20′ x 20′ x 8″ thick, were laid out and poured horizontally on the ground, one upon the other. When sufficiently hardened, the panels were raised to the vertical and hoisted by the use of a crane into their designated places.

A light-weight concrete mix weighing approximately 40 pounds to the cubic foot was used. This weight was achieved by the use of an exploded shale resembling gravel but extremely porous. Additional lightness was achieved by introducing an entraining agent into the wet batch which generates gases causing porosity to the mass. These aerating chemicals have the same effect on concrete as yeast has on bakers' dough. When sufficiently hardened, this light-weight concrete is less moisture absorbent than standard concrete, brick, or other masonry materials. Its coefficient of thermal conductivity is .17 BTU as compared to the insulative quality of .45 for standard concrete and .03 for cork. The roof was also poured in light-weight panels using zonolite, poured one upon the other, and raised in position on light steel supports.

At the present time, the kiln set-up contains four separate compartments with a capacity of 30,000 feet of lumber each. The compartments consist of 12 units each 64″ square x 16′ long. The dimensions of each chamber are 22′ high by 18′ wide and 22′ long.

The loading doors to the kilns, because of their size and weight of nearly

[1] Presented at a meeting of the Northern California Section, FPRS, Oct. 21, 1954, in Chico, Calif.

The Author: Peter Field holds a B.S. degree from the University of California. He has been associated with Ivory Pine Co., since 1950.

Front view of dry kiln, Ivory Pine Co. Walls are tilt-up construction, roof has zonolite panels, doors have 3-inch fiberglass insulation.

ton, demanded expensive commercial handling equipment. This was solved ingeniously and cheaply by a steel harness permitting the use of sawmill forklifts to take them out, move them around, and do whatever is necessary with them. The forks on the lift truck are removed and the pins and brackets which hold them are attached to hangers on the door; the top of the lift frame is fitted into a saddle higher up on the door, and the door is then ready for removal.

Air Circulation

The heat exchanger in each chamber is at the opposite end from the door. Directly above and below it are two 60" circulating fans. Each upper and lower fan is driven by a common shaft and both shafts are V-belt driven by one motor outside the kiln. There are two graphite impregnated bearings on each shaft within the kiln, lubricated and cooled by an alemite oil mist system. None of these bearings has had to be replaced in two years of operation.

The air travels laterally through the lumber twice, a distance of approximately 40'. Accepted principals of air circulation warned that this long air travel might subject the lumber to uneven drying or wet pockets. In two years of operation, this has not been the case. Four fine water jets were installed near the upper and lower fans. For steaming and conditioning purposes this finely atomized water is spraying against the hot heat exchanger and water vapor is formed.

Venting

Excess moisture is removed and outside air added by the use of two ventilating fans at the top of each chamber. Inside the kiln there are only three air openings each approximately 4" x 10" in area. These openings are in back of the heat exchanger, one even with the upper circulating fans, one even with the lower, and one directly between the two.

The opening and closing of these apertures is controlled by a single air cylinder hooked through air-operated pilot solenoid valves to the controlling instrument. When no moist air removal is called for, all openings remain closed. Consequently, when outside air is needed, and the fans are in up-draft rotation for example, two vents are opened, the bottom one sucking out moist air, the middle adding fresh air. When circulation is reversed the opposite is true, the top sucking out moist air while the middle one adds outside air.

There were a number of good reasons for going into this type of forced ventilation, instead of utilizing the conventional valves-in-the-roof method with shutters controlled manually or by air motors. The most important reason was that with the method used, air removal is much quicker and more positive, which is a definite aid in speeding the drying of lumber. This system is so sensitive that a 1.5° wet bulb change in either direction will cause it to operate, the adjustment often being achieved within 25 seconds.

As complex as this kiln may sound, its operation is extremely simple. Sixteen hours of the day, and on week ends and holidays, adjustments are made by the watchmen on the rounds. The kiln operator sets the recording-controlling instruments, changes temperature and humidity as necessary, and periodically reverses the air circulation. Little else is necessary in the mechanical operation.

There are a number of interesting controls and safety features in connection with the oil burner. The complete combustion cycle is controlled by what is called a Fire Eye. This is an electronic device, a German invention, utilizing a lead sulphide cell. It is about the size of a pencil eraser, and is connected by an electric cable to the main control box.

This Fire Eye looks through a tube at the side of the oil burner in a position so that it can scan the oil flame at all times. When the recording-controlling instrument calls for heat, the first step in the burner operation is to ignite a butane pilot light. This has to remain steady and of a yellowish color in order to energize the Fire Eye and permit the starting of the burner motor and start the flow of oil. If at any time the flame should become smoky, change in color or go out, the Fire Eye would immediately stop the oil flow and signal its action. At no time is there any possibility of raw oil shooting into the combustion chamber.

In case of fire within the kiln, the excessive temperature will operate through the Fire Eye, stop the oil burner, actuate the water sprays and close all vents. This total lack of oxygen plus the circulation of supersaturated air would quickly extinguish any blaze, with little damage to lumber or kiln.

The final test of any kiln is how well it dries lumber, how rapidly, and at what cost per M. These kilns were designed to dry 650 M per month. In actual operation, month after month, this output has been nearly doubled.

With correct air baffling there have been few instances of pockets of wet lumber. Upon examination these pockets could always be traced to the failure of the kiln operator to use the baffles properly.

However, its greatest advantage over conventional steam kilns is in its low operating cost of $2.83 per M board feet. This includes the depreciation charge of $.88, charging and supervision labor $.40, maintenance $.15, fuel oil $.73, and electric power $.48.

In the long run we feel that heat exchangers are the coming means of heating dry kilns. There are no boiler and firemen expenses and the fire danger of an internal burner is not present. With more and more lumber operations going from steam to electric power, the idea of the heat exchanger for the dry kiln seems a practical step forward.

One chamber of kiln with door removed. Note four 62-inch high units, one above other through use of target line system; baffle at both sides of lumber and 4 x 4 inserts between units; movable brace at top of unit.

Back interior side of the kiln. The heat exchanger is behind horizontal and vertical baffle. Note the open bottom vent, closed top vent, wet bulb thermometer at lower left, atomizing sprays at top and bottom.

Heat exchanger from below showing two 72-inch fans with two graphite impregnated bearings into which oil mist tubing injects.

Forest Products Research and Education at Michigan State College[1]

H. J. RAPHAEL and JAMES W. GOFF
Department of Forest Products, Michigan State College, East Lansing, Mich.

Describes research and education facilities of Department of Forest Products, Michigan State College. Cooperative studies are conducted in logging and milling, seasoning, wood machining, preservation, plywood, gluing, finishing, wood anatomy and physical properties, and packaging.

RESEARCH AND EDUCATION ACTIVITIES for the forest products industries are carried on at Michigan State College by the Department of Forest Products. This is one of four departments comprising the Division of Conservation; Forestry, Fisheries and Wildlife, and Land and Water Conservation are the other three.

The campus at East Lansing is ideally situated for taking field trips, enabling classes to make numerous visits to forest products industries located at Kalamazoo, Grand Rapids, and Battle Creek.

The department takes part in the extension programs and continuing education programs administered by the college. Through these mediums, education and aid in forest products problems are carried to all parts of the state of Michigan.

Facilities

The Department of Forest Products is housed in four buildings. Three are located in the central portion of the campus, while the fourth, housing the sawmill, is situated on the eastern edge of the college property. The main departmental building contains 9,000 square feet of floor space and houses the general departmental office, offices for staff and graduate assistants. Several classrooms and laboratories devoted to studies of wood anatomy, gluing, preservation, seasoning, finishing, and wood machining are also located in this building.

Adjacent to the main building is the Forest Products Annex which contains offices for the balance of the staff, wood chemistry laboratory, and facilities for research work in wood anatomy. The Packaging Laboratory is the third structure in the Forest Products group and is devoted to laboratories for the construction and testing of all types of containers. At present this building also houses the equipment used for the mechanical testing of wood, since much of the apparatus is used in both areas of teaching.

Sawmill facilities are described under Logging and Milling.

The Kellogg Center for Continuing Education, located on the campus at Michigan State, provides conference rooms, and dining and sleeping accommodations for several hundred people. This center is frequently used for forest products conferences and conventions sponsored by the college and by industry.

Logging and Milling

Eight woodlots within walking distance of the campus and several woodlots and college-owned forests throughout the state offer ample opportunity for the study of logging engineering. Equipment available in this field includes an International T–9 tractor, a 6-ton logging truck, numerous gasoline and electric powered chain saws, plus the usual hand tools and instruments.

Research and instruction in the various phases of milling are conducted in a modern sawmill building measuring 120 feet by 60 feet. This building houses a 56-inch circular mill (Fig. 1), a 6-foot band mill, two edgers, an automatic small-log band mill, a German sash gang mill, a trimmer, a 24-inch surfacer and a 14-inch jointer, plus a conveyor and blower system. In addition to the main building, a 20-foot by 40-foot wing contains machinery and equipment for filing and tensioning band, circular, and sash saws. Included in this wing is a machine shop equipped with an engine lathe, surface grinder, and milling machine.

Seasoning

Drying studies are carried on in the main building of the central group. An experimental Standard forced-circulation dry kiln of approximately 3000 board foot capacity is the main drying unit (Fig. 2). Additional equipment used in kiln drying studies includes a velometer for measuring air velocity in any portion of the kiln, an electric hygrometer and thermometer for measuring relative humidity and temperature at any point in the kiln, a potentiometer, and a number of electric moisture meters. The usual equipment for obtaining oven-dry weights is available.

Wood Machining

The woodworking shop is equipped with a 16″ radial saw, a 16″ universal saw, a 10″ universal saw, a 36″ band saw, a 12″ band saw, a 12″ chop mitre saw, a 6″ jointer, a 12″ single surfacer, a single-spindle shaper, two single-spindle drill presses, two 12″ lathes, a 6″ vertical belt sander, and a 7″ by 4′ horizontal stroke sander. A number of power hand tools including saws, routers, a plane, and drills are also available, as are the usual hand tools.

Preservation

The preservation laboratory houses a small pressure cylinder measuring 12″ in diameter by 4′ in length and a larger pressure cylinder measuring 24″ by 8½′ in length (Fig. 3). Each cylinder has a separate working tank mounted on a scale, and in addition the larger cylinder is equipped with a Reuping tank. Pressure and temperature are maintained within close tolerances by means of automatic valves and indicator-controllers. A laboratory model dry-vac system is also available for instructional purposes.

Plywood and Gluing

Facilities for gluing studies include a 36″ by 51″ production hot press (Fig. 4), a 30″ laboratory glue spreader, a small laboratory hot press, and refrigerated glue storage. A twenty-point indicating potentiometric pyrometer is also available for determining glue line temperature at any point in a plywood panel during the curing cycle.

A plywood shear testing machine is located in the wood testing room of the packaging laboratory across the street from the main building (Fig. 5).

[1] A contributed article.

Finishing

Equipment used in the study of wood finishing includes a DeVilbiss Universal spray booth, apparatus for determining finish characteristics such as film thickness and abrasion resistance, and the usual sanding equipment necessary for preliminary surface preparation.

Wood Anatomy and Physical Properties

Basic equipment for the complete study of the physical properties of wood is available in this laboratory. In addition to this, the facilities available include a Leitz Panphot Universal Microscope and Reflex camera, a sliding microtome (Fig. 6), and complete darkroom facilities.

Packaging

The packaging laboratory consists of three rooms. The largest is equipped with cutting and scoring equipment for paper and fibre board, stitching equipment, staplers, and taping equipment for the manufacture of sample fibreboard containers and folding cartons. This room also houses a 400-pound capacity package vibrator equipped for circular, linear, and nonsynchronous circular motions, a 16-foot Conbur tester, a divided table drop tester, a free-fall drop tester with an electric chain hoist for heavy articles, and a small platen press.

A second room is maintained at standard temperature and humidity for the testing of paper, paperboard, and cellulosic films. The apparatus in this room includes a small box compression testing machine (Fig. 7), a Mullen tester, two internal tear testers, a Sutherland rub tester, two paper micrometers, a comparator, a basis weight scale, and an automatic analytical balance. This room is also used for the conditioning of paperboard containers prior to tests on the larger apparatus outside the conditioned room, and for the storage of cellulosic materials.

The third room in the packaging laboratory is used for the physical testing of wood, non-hygroscopic container materials, and complete consumer and shipping packages. Apparatus available includes a Riehle motor-driven plywood shear tester, a glue block shear tester, electronic equipment for measuring velocity shocks suffered by packaged articles and for the testing of cushioning materials under dynamic loads. Equipment for the sonic testing of materials, for the measurement of gas and water vapor permeability of materials and for the heat sealing of plastic films is also housed in this room. Auxiliary equipment includes an Orsat gas analysis apparatus, a Pitts gas analyzer for micro-analysis of gas samples, dipping tanks for the preservation of metal parts, and a large vacuum oven.

Fig. 1.—Large sawmill installation operated and maintained by Department of Forest Products. Circular mill shown is housed in one corner of the building.

Research

All of the above outlined facilities are available for research work, although priority in their use is given to instructional needs. Projects currently under way include a study of markets and methods of utilization of low grade hardwoods, work on the effect of saw chain design on power consumption and cutting time, cooperative efforts with the U. S. Forest Products Laboratory on the relation of saw tooth design to power consumption in sawmilling operations.

In addition to the above, work on the development of a design for field assembled wood trusses to be used in residential building is being carried on, as is cooperative work with the horticulture department at the college on the development of film crate liners for the modified atmosphere storage of fruits and vegetables. A new project underway involves methods of high temperature drying of wood.

Results have recently been published on several completed studies. Among these were an investigation of methods of chemical debarking of aspen, a log-grade lumber-grade yield comparison, and an investigation of the relation of bark appearance to the occurrence of figure in sugar maple.

These research projects were carried out in cooperation with the U. S. Forest Products Laboratory and private industries.

Course Program

The department offers undergraduate and graduate programs of instruction. The graduate instruction leads to the degree of Master of Science in any field of specialization, and to the degree of Doctor of Philosophy in Wood Technology.

To meet the diversified requirements of industry for technical and sales per-

Fig. 2.—Forced circulation Standard Dry Kiln has capacity of about 3,000 board feet.

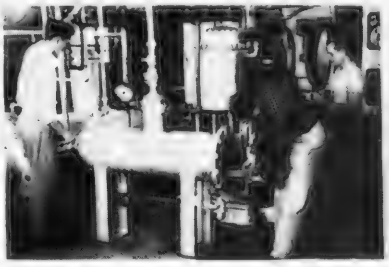


Fig. 3.—Improving properties of wood through impregnation is an important phase of forest products training. Students are loading 12-inch experimental retort in fully equipped and automatically controlled laboratory.

Fig. 4.—Equipment of plywood laboratory includes production-type hot press, shown being loaded with plywood test panels.

Fig. 5.—Adhesive qualities of various wood glues are evaluated, using a Riehle plywood shear testing machine.

Fig. 6.—A fully equipped laboratory for the study of wood anatomy is maintained. Student is preparing thin sections of wood with sliding microtome.

Fig. 7.—Student tests a regular slotted container in compression, for comparison with ring stiffness values of the corrugated board components.

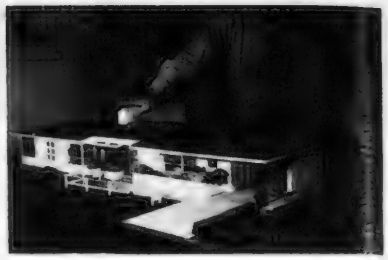


Fig. 8.—Residential building students construct their own models and estimate costs of materials.

sonnel, the undergraduate training is divided into five fields of specialization:

Wood Utilization equips graduates for production and supervisory positions with the forest products industries. Students acquire a thorough knowledge of the properties and uses of wood, and study intensively various phases of wood conversion. They also receive training in business, economics, quality and cost control, and industrial management, as it applies to the forest products industries.

Wood Technology prepares graduates for positions in the development and research organizations of the forest products utilization field. Stress is placed on the physical sciences. It is expected that students electing this major will continue with post-graduate studies.

Lumber and Building Materials Merchandising trains men in the merchandising of lumber and other building materials, and acquaints them with the principles of residential building and business administration. Graduates of this course readily qualify for positions in the wholesale and retail lumber and building materials merchandising industries. Ultimately, some graduates have established merchandising organizations of their own.

Residential Building graduates qualify to enter building organizations as supervisors, assistants to building superintendents, estimators, and building materials purchasers. Positions in the real estate, home financing, and insurance fields are also open to them. The ultimate aim of most graduates is to establish a building organization of their own.

Packaging Technology trains men for production and development work with container manufacturers and for supervisory positions in the packaging and materials handling departments in industrial, public, and transportation organizations. Emphasis is placed on engineering and economic problems connected with the design, manufacture, and use of containers. Industrial and traffic management and materials handling are also stressed.

Since practically all graduates of this department will find employment with private industry, it is considered desirable for the students to have some first-hand, practical experience at the time of graduation. All students are therefore required to get 16 weeks of practical experience in some phase of work related to their chosen profession before they can be recommended for graduation.

Staff

James J. Casey teaches courses in building materials and house design. He holds the degree of Master of Arts and Architecture from the University of Florida. He served in the U. S. Air Force during World War II and has had experience in building design and construction.

J. Wallace Creighton, Ph.D. (Wood Technology) University of Michigan, is on a half-time teaching and half-time research basis. He teaches courses in lumber drying, woodworking machinery, and quality control, and is in charge of the department's experimental sawmill. His industrial experience includes log buying, sawmill operation, and veneer manufacture. He spent two years in South America for the Foreign Economic Administration operating dry kilns, supervising mill construction, and inspecting lumber.

James W. Goff, M.S. (Wood Technology) Michigan State College, is in charge of courses in package technology. He was an engineer with the U. S. Army Ordnance, Package Specifications Division, during World War II and has been associated with the General Box Company.

John L. Hill, D. Forestry (Wood Technology) Yale University, teaches courses in plywood and wood gluing, timber physics and structural design, wood identification, and wood finishing. Dr. Hill served in the U. S. Army during World War II and has been engaged in tropical wood research at Yale University.

Peter Koch, Ph.D. (Wood Technology) University of Washington, also holds a degree in Mechanical Engineering from Montana State College. He was associated with the Stetson Ross Machine Company as assistant to the president, and has been a machine designer and consulting engineer. He will be a research specialist in Forest Products upon his arrival in July.

William B. Lloyd, M.S. (Forest Utilization) New York State College of Forestry, has been a residential builder, retail and wholesale lumber salesman, and millwork salesman. He served with the U. S. Air Force during World War II and is in charge of courses in residential building and lumber merchandising.

Alexis J. Panshin, Ph.D. (Wood Technology) New York State College of Forestry, is head of the Department of Forest Products and teaches advanced courses in wood anatomy and properties, and wood finishing. He has been associated with the U. S. Forest Products Laboratory and was Wood Technologist with the Higgins Aircraft Corporation during World War II.

William C. Randel, M.S. (Forestry) New York State College of Forestry, has been employed as an industrial forester and timber buyer. He also had his own logging and sawmilling business in New England. He teaches courses in milling, logging engineering, and forest products industries.

Harold J. Raphael, Ph.D. (Wood Technology) Michigan State College, served in the U. S. Navy during World War II, was a retail lumber salesman, and was engaged in wood preservation research at the Oregon Forest Products Laboratory. He teaches wood identification, wood and paper technology, wood preservation, microtechnique, and forest products industries.

William G. Stump, B.S. (Forestry) Iowa State College, is extension specialist in forest products. He was a farm forester and has been engaged in log and lumber buying and inspection

The Economic Importance of Wood Residue in the South[1]

WALTON R. SMITH

Chief, Forest Utilization Service, Southeastern Forest Experiment Station

Survey was made to determine quantity, quality, and availability of wood residue in North Carolina. Procedures were developed which can assist other states in carrying out similar projects.

ALL OF THE WOOD that goes into the pulp mills in the southeastern states is merely poured down the drain.

Such a statement is utterly ridiculous because everyone knows that the wood that goes to the pulp mills produces valuable products in the form of paper, fiber board, corrugating board, rayon, and other items that have tremendous importance to the economy of the South. It is also known that a good price is paid for this wood, that the labor transforming it to pulp and paper products is more highly paid than labor in many other southern industries, and that the entire industry has been a boon to the South with its failing cotton.

The statement is made merely to call attention to a comparable volume of wood residue that does either go up in flame, rot in the woods, or stymie industry with its problem of disposal. This, of course, refers to the large volume of wood that is left in the forests, that is left at the sawmills, or that accumulates as waste at the manufacturing plants of the Southeast.

Although there are really no good estimates of the volume of wood waste in the Southeast, the best information available to date for the entire territory is the result of a Forest Service reappraisal of 1945. It was found that nearly 700 million cubic feet of wood residue accumulates each year in the woods and in the primary manufacturing plants. No estimate was made of the amount that accumulates in the secondary manufacturing plants.

By converting this volume of wood waste into cords, it amounts to more than 8½ million cords of wood waste annually in the Southeast. The Southeast, as designated in the Forest Service reappraisal study, included Georgia, Florida, Alabama, Mississippi, and Tennessee.

By referring to Forest Survey Release No. 72 of the 1952 pulpwood production in the South, it is found that these same five states (four of them leading the entire southern states) produced a pulpwood total of 7,838,000 cords. From this quick and rough estimate, it can easily be seen that production of waste in the logging and primary operations only, could more than supply the pulpwood needs if the material were readily available and of suitable form.

If these figures have established a picture of the quantity of the woods waste available in the South, the picture can be undercut by stating that the figures given on wood residue or wood waste are not much more than a good guess. Unfortunately, this material has been considered as wood waste in the past and no one has been too concerned with the problem of finding out just what does exist with respect to not only quantity but quality, availability, and cost.

Broad Outline

The Forest Service made some studies of wood waste in the reappraisal of 1945 and again in 1953 similar studies were made which will probably be published next year. Both of these studies of wood residue represent rough approximations. To cover the entire country, only a few locations could be sampled and the figures expanded with a large factor. Although there will be some inaccuracy at the local level, at least some information is available on a regional or national level that will realistically reveal the wood residue situation in its broad outlines.

One thing learned is that the location and concentration are of supreme importance. The trouble with many big piles of slabs deep in the woods is that it costs more to get it out than anybody can possibly make from it.

Many local studies of wood residue have been made in the South. Fine work was done by Egon Glessinger in his estimate of waste in the State of North Carolina, which was based on Forest Survey data; a later study of Lenthall Wyman of North Carolina State School of Forestry, in which he applied waste factors to census bureau lumber production data by counties; Carpenter's study of the amount of chippable waste at southern pine sawmills published in 1950; King's survey of sawmill residue in east Texas published in 1952; and Todd's sawmill and logging residues in the South Carolina Piedmont published in 1953. All of these studies were good and contributed information to the general situation on wood residue in the South. But as far as is known there have been no extensive studies of wood residue in the three states represented by this section: Florida, Georgia, and Alabama.

The Forest Utilization Service, cooperating with the North Carolina Department of Conservation and Development, is now completing a survey of quantity, quality, and availability of wood residue over the entire State of North Carolina. The State of South Carolina is proposing to conduct a similar study during the coming year. It is hoped that Georgia, Florida, and Alabama will follow suit as the need for such studies is urgent.

In the wood residue study in North Carolina, procedures have been developed that may be helpful to others. In the first place, estimates of wood residue are confined to the primary and secondary wood-using industries. Separate data is being obtained for small sawmills that cut 3 million feet or less each year, for large sawmills, for concentration yards, for furniture plants, and for miscellaneous wood-using industries.

For each of these groups of industries, the study of determining the quantity of wood waste that is produced; the nature of the waste, whether it is in the form of slabs, trim ends, edgings, shavings, sander dust, etc.; the present use of that waste, whether it is used for fuel, burned for disposal, or sold for some purpose; the availability

[1] Presented at the annual meeting of the Florida–George–Alabama Section, Forest Products Research Society, October 29, 1954, at Auburn, Ala.

The Author: Walton R. Smith received B.S. from N. C. State College. He was associated with U. S. Forest Products Laboratory and Weldon Lumber Co. before appointment to present post. Author of numerous papers, Smith has served as Trustee and Chairman of Carolina-Chesapeake Section, FPRS.

of the waste material, if it were purchased at the site of its production or if it had to be hauled to a concentration yard 30 or 40 miles away; and the cost of the waste at the point of production or transported to a concentration yard. In addition to this basic information, data were collected on the stability of the mills producing the waste, the types of equipment used by plants producing waste, and general information regarding the wood residue situation.

Sampling Section

The most difficult part of the wood residue study was obtaining information from the more than 4,000 small portable sawmills scattered over the state of North Carlina. To obtain the information the State was divided into four physiographic areas corresponding to the mountains, the Piedmont, and the upper and lower end of the coastal plain in the eastern part of the State.

These areas were broken down into sub-areas comprised of 8 or 10 counties. In each of these sub-areas, several townships were randomly selected as sample areas and a complete field coverage of these sample areas was made to obtain information on all small sawmills that produced lumber within those sample areas during 1953. This was a bigger job than anticipated and it involved the collection of data from some 200 small portable sawmills. However, excellent information was obtained by conducting the study in this manner.

For the large sawmills, the lumber concentration yards, the furniture plants, and the miscellaenous wood-using industries, lists of these more permanent plants were available and considerable information was obtained from them by a mail canvass. This mail canvass information was supplemented with spot field checks of both respondents and non-respondents. A response of better than 50 per cent was received from these industries.

During the course of field work on this wood residue study, tremendous interest was found in all classes of wood-using industries in the survey and in the possibility of assisting in developing new outlets for wood waste. Many letters were received from the wood industries themselves, from chambers of commerce, and from other interested individuals who offered to assist in collecting more complete information on certain localities to help in developing a market for this material.

The data is being analyzed and a report prepared which will be published in cooperation with the N. C. Dept. of Conservation and Development. Although complete results of the survey are not available, it is certain that the quantity of wood waste is going to exceed any of the previous measurements, some of which were thought to be far too high, and that great quantities of usable wood waste in solid form, not counting sawdust and shavings, are available at a reasonably low cost and begging for industrial use. During the course of the survey, the staff was instrumental in helping to locate a plant for making chipboard out of hardwood in the central part of North Carolina.

Why is such a detailed survey of wood residue needed and will any good come of it? Those in forest utilization research work are most optimistic about the utilization of this wood residue for useful purposes and at a profit. During the past ten years the development of new uses for wood waste has been watched with eager interest. It is believed that during the next ten years the majority of solid wood waste will be converted into useful products.

The first and perhaps the most important conversion will be in the use of slabs, edgings, and end trims and solid wood waste into pulp chips for shipment to pulp mills. Some of this has occurred during the past year or so, particularly the use of pulp chips by the Camp Manufacturing Company at Franklin, Va., by the International Paper Company at Georgetown, S. C., and Mobile, Ala., by the Union Bag and Paper Company at Savannah, Ga., and by many new ones that every month are getting into the field of utilizing pulp chips produced at sawmills.

The key to this situation has been the development of log barkers and semi-portable chipping equipment. Today there are several agencies working on a slab debarker and, although a suitable one has not yet been perfected, several models under development show great promise. Within another year a workable slab debarker at a reasonable price may be on the market. Portable chippers that make very satisfactory pulp chips are already available at a reasonable price.

Outlet for Waste

As soon as the slab debarker is available, pulp companies will be setting up slab concentration yards just as they now have pulpwood concentration yards. The many medium-sized sawmills will be installing slab debarking equipment and chippers. The larger sawmills will continue to install log barkers and chippers to convert all of their waste into pulp chips. This increasing volume of wood residue going to the pulp mills will not only help to supply their needs for raw material, but will offer an outlet to the sawmill man for a material that has been a cost and a bother in the past.

The pulp mills are not the only industries interested in solid wood waste. The market for chipboard and fiberboard is expanding tremendously as new uses are developed for these materials and the technique for manufacturing them becomes more simplified. Today, there are a number of companies looking through the South for possible locations for these plants. In seeking a location one of their first considerations is the amount of cheap raw material that they can obtain to operate their plant. When adequate supplies of solid wood waste are available at a reasonable price, these companies are interested in locating their plants in such an area.

So far, the two main possibilities for utilizing solid wood residue have been pointed out. There are also opportunities for utilizing shavings and sawdust for the manufacture of asphalt roofing, bedding, insulation, explosives, plastics, and similar products. Another promising use of the fine wood residue material lies in the manufacture of briquettes for fuel. Briquetting of wood waste has been done for many years in the West and now more evidence of it is seen in the East with one or two plants already utilizing this process. As the market demand increases for this type of fuel, additional opportunities will be available for the wood-using industries in the area.

Chemical Research

The above are only the uses of wood residue that are in existence and under way in the South today. A vast array of possibilities lies over tomorrow's horizon and several hours could be spent dreaming about what is going to be done in the chemical utilization of wood residue. This subject was covered very well in the F–G–A annual meeting last year by Dr. Edward G. Locke, Chief of the Division of Derived Products of the U. S. Forest Products Laboratory, Madison, Wis.

Some amazing transformations of the cellulose into many chemical products have been made at the Laboratory, including sugar, alcohol, glycerine, molasses, and a host of other materials. The chemists are hard at work in finding new uses for wood and practically all of these chemical uses will fit right into the picture of utilizing wood residue. Before long probably a number of large chemical industries in the South will be depending on wood cellulose for their raw material. The oil and coal reserves that have caused the expansion of the great chemical industries in this country were derived from cellulose a million or so years ago. The petroleum companies have not been niggardly in the amount of money they were willing to spend on research to crack the chemical problems of these raw materials, with the result that

thousands of products are made today which bear little resemblance to petroleum and coal. Is there any good reason why the living cellulose in the tree does not contain the basic chemicals that will permit a comparable development in the wood chemical industry? The future is bright and so-called wood waste is in actuality a valuable raw material of commerce of the future.

Thus the importance of these surveys of wood residue and why they are so urgently needed for Georgia, Florida, and Alabama is obvious. The trend is already here and companies are looking for plant locations where wood residue is available in quantity. They not only need to know the quantity of wood available, but they need to know something about its quality, its availability, and its cost. Where this information is readily on tap, they will be more willing to invest their money and establish plants than they would be if they had to make their own surveys and compare one location with another.

The responsibility for conducting these surveys should not rest with the federal government, although it is the duty for those in forest utilization research to assist in every way possible in promoting and in helping plan such studies. It appears that the State Forest Services and the State Development Boards that are looking for new industries should coordinate their efforts in carrying out such surveys in every southern state so that they can receive their share of new industries looking for southern locations where wood residue is plentiful.

By-Products from the Redwood Lumber Industry[1]

ROBERT W. MILLER

Assistant Director of Research, The Pacific Lumber Co., Scotia, Calif.

Long range policy of fundamental and applied research was formulated with ultimate objective of complete utilization of basic raw material sources. Some products developed under this program are discussed.

TWO DISTINCT SPECIES of redwood are recognized in the industry. One is the *Sequoia sempervirens* or coast redwood, which is confined to a fog belt within 30 miles of the Pacific Coast from southern Oregon to Monterey County in California. The other is the mountain redwood or *Sequoia gigantea*, which occurs on the western slopes of the Sierra Nevada and obtains its maximum development in Sequoia and Kings Canyon National Parks in California. From the commercial point of view we are concerned only with the coast redwoods and this paper deals with this species in northern California.

On slopes, the coast redwoods rarely exceed 225 feet in height and 10 feet in diameter. On flats, trees have been found up to 300 feet in height and 20 feet in diameter. The flats, however, constitute only a small percentage of the forest. The coast redwood belt is estimated to contain about 50 billion feet of virgin redwood now standing.

Large bodies of forest in accessible places, many along the Redwood Highway, have been set aside for park and recreational purposes. Nearly all the timber now being cut comes from the rugged slopes of the back country where the land is useless for anything other than the propagation of forests.

The Pacific Lumber Company has balanced annual cut with the annual growth on cut-over land. Like other lumbering operations which practice conservation, selective logging, and sustained yield programs, our company has reasonable expectation of being around for a long time to come.

Unusual Properties

Early in the period of development, the management realized that a lumber operation based on the raw material, redwood, called for facilities and operating techniques quite different in some respects from the practice generally followed in mass production sawmill operation. Redwood is a specialty wood. Its market acceptance has been mainly for specialty uses, and markets require quality manufacture to capitalize fully on the unusual physical and chemical properties of the species.

In the field of diversified utilization and by-products development, our management has fostered a long-range policy of fundamental and applied research, based on the ultimate objective of complete utilization of basic raw material resources. This program has included both virgin and new growth timber and looks forward to the day when all wood substances not adaptable to lumber products will be converted in by-product plants equipped for mechanical and chemical processes, thus utilizing all the wood resources of the forest.

One such by-product development is the present utilization of the fibrous bark peeled from the redwood logs before milling. Whereas the bark, which could run to 20 cords or more for each 5000 feet board measure of redwood lumber, might have been left in the woods or otherwise disposed of, it has found instead a national market in insulation and industrial applications.

The thickness of the crude bark depends upon the age of the tree and the previous position of the log in the tree. In old growth redwood, the bark may run from 6 to 10 inches in thickness in the first cut log and from 2 to 3 inches in the upper cuts. The length of the bark slab is the length of the log.

From these dimensions you can see that the bark slab is comparable to a regular wood slab and as such might be processed to chip form for certain waste utilization processes. This is, in fact, true; the bark in chip form is readily handled in regular digestion operations.

In the preparation of our bark fiber insulation, the redwood bark is shredded in a hammermill operation, following which it is cleared of debris and dried. Finally, the bark fiber is baled to produce a prime bale of 300 pounds which is sawed into thirds to complete the manufacturing operation. This finished product is known as *Palco Wool* insulation.

One of the oldest uses for redwood bark fiber has been as a loose-fill insulation. The Palco Wool supplied for this purpose represents a shredded product of fairly long fiber bundles still containing some of the short-fibered cells which adhere to these bundles. These

[1] Presented at a meeting of the Northern California Section, FPRS, Sept. 30, 1954, in Scotia, Calif.

The Author: Robert W. Miller received B.S. degree from Penn State University, M.S. from Institute of Paper Chemistry, Appleton, Wis. He was chemical engineer with Simpson Logging Co. and process control supervisor with Masonite Corp. before accepting his present position in 1950.

do not interfere with the efficiency of the loose-fill insulation. The material is applied at a density of approximately 5 pounds or less per cubic foot. At this density very little settling results, even over long periods of time and under fairly severe vibrating conditions.

Insulating Properties

Its usefulness as an insulator is due to its inherent permanence and durability, its high factor of resilience, and its low thermal conductivity. These properties have gained for redwood bark fiber a wide acceptance as a cold storage and frozen food insulation material, as a house insulation, and for similar applications.

The Palco insulation alone is unusually fire-resistant for a cellulose fiber but, for certain uses, it is desirable to provide a greater degree of flame resistance than is inherent in the material by virtue of its unique composition. As a result, we have developed a process which is called the Saferizing process; all bark fiber produced for domestic insulation purposes is given this treatment.

The fine fiber and bits removed from the whole bark following the shredding operation are further fractionated to yield a super-refined product known as *Fiber A,* which is also prepared in bales for shipment. This finer fiber finds use in oil filters for Diesel engines where, blended with cotton, its physical characteristics together with the resiliency of the blend give a good flow factor and satisfactory filtering performance.

Fiber A has been used to the extent of a 40 per cent replacement of cotton in mattress filling. The bark fiber adds to the resiliency of the product and the blend picks up moisture more slowly and releases it more rapidly than does cotton alone. This is a definite advantage, particularly where the mattresses are used under humid conditions.

Battery Separators

In spite of the fact that bark fibers are not of great interest as components of conventional paper furnishes, a sheet containing only Fiber A has been developed for use as separators in electrolyte-retaining types of batteries. The redwood bark fiber sheet retards the shedding of the plate so that no sediment space need be provided and permits the use of larger, higher capacity plates with no increase in the over-all cell size. This sheet has also contributed definitely to the "non-spill" and "dry-charge" features of the battery.

Bark fiber sheets have been used for resin impregnation and subsequent lamination. The fiber has been used as a filler for molding powders and has other useful industrial applications.

The dust and fiber debris remaining after the removal of the earlier mentioned fractions is not discarded. Under the trade name of *Palco Pete,* this residue finds use as a special mulch and soil conditioner where it functions to increase the moisture holding capacities of the soil and to permit better aeration.

A point to note in this connection is the longer life of the bark material in the soil in contrast to materials such as peat moss, for example. This property is of interest to the raisers of hot-house orchids. They find that the use of the bark material mixed with the soil necessitates less frequent re-potting of the plants.

Perhaps the ultimate fraction of the whole bark is the so-called bark dust, which may be recovered as a fine amorphous powder. The uses for this material are related rather more to its chemical nature than to its physical form and uses for this material are under development.

Leaving the bark for the moment, the dry waste from the lumber converting operation is almost entirely used for the production of *Pres-to-Logs.* No doubt you are generally familiar with Pres-to-Logs and their method of manufacture by extrusion of the hammer-milled, dry waste from water cooled dies. As a result of the friction which develops from filling the die, temperatures up to 450° F. are created and, in the case of the redwood Pres-to-Logs, one finds an added advantage in the thermoplastic characteristics of the extractives, which are utilized in binding together the finished log.

The redwood Pres-to-Logs tend to be hard and firm, producing a steady heat without sparks. They are suitable for cook stoves, heaters and in many other similar applications. Because of their desirability as a fuel, they find a ready market throughout the West Coast area.

Plastics Component

During World War II a certain impetus was given to the use of redwood pulp in plastics. This use was based on the discovery that when redwood in chip form is cooked with high pressure steam, certain of the extractives, notably the tannins and phlopaphenes, are so modified that they combine with the other wood components, either as such or in a modified form, to yield a pulp superior to redwood flour as a basis for certain further plastic operations.

An example of a commercial operation utilizing the principle of activating certain components of redwood by means of high pressure steam cooking is the Masonite Corporation's plant at Ukiah, California. There they employ as a raw material waste redwood in chip form for the manufacture of their Duolox hardboard.

One of the subsequent developments in the use of redwood pulp products has been the application of such pulps to oil well drilling muds to prevent loss of circulation during drilling operations. This pulp is currently being produced at Scotia under the trade name of *Palco Seal.* It is packaged in 40 pound bags for ease of handling at the drilling site. Varying amounts of pulp are added per barrel of drilling mud, the amount depending upon the porous conditions of the formation through which the drilling fluids are being lost. Technical data developed through research and commercial operations show that the product is extremely effective for this purpose.

Due to the low pH existing during the cooking with high pressure steam, even for short intervals, acid hydrolysis takes place in the chips and approximately 15–20 per cent of water soluble materials are generated on the basis of the oven-dry pulp produced. This water soluble fraction contains degradation products of the wood which may B-2918—Forest Products Galley 38 be of interest from the standpoint of chemical recovery. Yields of pulp can be controlled by suitable pH adjustment of the chips before cooking.

Road Binder

Of some interest from the standpoint of waste disposal or recovery is the use of the aforementioned water soluble fraction in concentrate form as a temporary road-binder for dirt roads in sections experiencing long, hot, dry summers. This material is effective in preventing dust blow-off and has the advantage of becoming harder when exposed to heat and desiccation.

Laboratory pulping experiments on either non-extracted or extracted redwood chips have demonstrated that the sulphite, nitric acid, or kraft processes can be used, and that the resulting pulps can be bleached to a brightness of 80 using conditions in these operations which approximate normal commercial practice. The best strength characteristics were obtained by the kraft process.

From the standpoint of strength and absorbency, Asplund fiber produced from redwood chips is very suitable for use in the manufacture of impregnating felts. Either heat alone or heat and chemical treatment may be employed on the chips prior to defibering. The chemically pretreated chips are the best but give lower fiber yields. Bulk quantities of chips are regularly furnished by redwood mills for this or other operations employing waste wood in chip form.

Another item of interest is the recovery which can be effected by means of edge and end gluing operations applied to odd lengths and widths of kiln

dried lumber. Our mill at Scotia employs this method of recovery in connection with a factory operation and reduce materially the quantity of wood going to waste.

The latest development in our by-products program has been the establishment of a pilot-production plant for the recovery of extractives from the whole bark and the manufacture of a two-inch, structural-type, low-density insulation board from the extracted redwood bark pulp residue.

As mentioned earlier, redwood bark slabs are of suitable proportions for chipping in a conventional chipper. The prepared chips are digested in a pressure vessel by a neutral sulphite process or variations of this. Following discharge from the cooking operation the solubilized portion is separated from the pulp by conventional pressing and washing methods.

The soluble fraction is recovered from solution by carefully designed processing techniques to yield a dry granular material known as Palcotan. This material is available in 50 pound bags and is finding broad and diversified industrial use as a deflocculating agent. One of the principal uses is as an additive in oil well drilling muds.

Other outlets for this material in various stages of development or use include the fields of leather tanning, battery paste manufacture, master batching of rubber latex, ore processing, ceramics and boiler water treatment. Numerous other applications involving dispersant, binding, or stabilizing properties can be visualized.

The bark residue from the extraction is combined with woodfiber from the steam treatment operation and after mild refining in an attrition mill, so as not to materially reduce the inherent fiber length, the stock is formed into a board by deposition from a water suspension. The formed board, when dried and laminated, is cut to nominal 1′ x 3′ or 2′ x 4′ sizes in a 2-inch or 3-inch thickness for use as a structural type insulation material. The board has a nominal density of 9–11 pounds per cubic foot, a compression of about 2 per cent with recovery from 70–90 per cent, a water absorption of 5–6 per cent by volume, and a modulus of rupture of 60–80. The board can be manufactured in a broad range of densities, though the most popular to date has been the 9–11 pound range.

Conclusion

This, briefly, is a review of the by-products developments in the wood waste utilization program in the redwood industry. The majority of the investigative and research data accumulated by our company to date has been done in conjunction with the Institute of Paper Chemistry at Appleton, Wisconsin, during the past fifteen years or so. We are presently implementing research facilities at Scotia to carry on applied research in connection with the new board and chemical pilot production plant and all phases of the by-products program.

In closing, it should be pointed out that when the price of lumber is high, the return is more than sufficient to balance the hidden costs resulting from the large amount of waste. It is conceivable that in leaner times when the price of lumber is low, it may not continue to cover these hidden costs and production of lumber may well feel real problems of manufacturing cost and sales return.

It is necessary, therefore, for all wood-consuming industries to examine the possible potential value of the residual waste and thus spread the costs which are now chargeable only against lumber. In this residue, instead of waste, might be found values in excess of the current assessed value of the whole. A thoughtful realistic approach to this problem must be considered by every organization dealing with the conversion of timber to lumber.

Converting a Steam Plant from Coal to Hog Fuel Burning[1]

W. H. RAMBO

Industrial Plant Engineer, Portland, Oregon

Substitution of low cost hog fuel for coal and oil fuels is feasible and economical in areas where adequate hog fuel supplies are available. This paper discusses hog fuel composition, efficiency and other advantages, types of hog fuel burning equipment, and necessary plant modifications.

ABOUT TWO YEARS AGO, we were contacted by the Thornton Lumber Company regarding the feasibility of converting two of the four boiler units of the Montana State University steam plant from coal to hog fuel burning.

This company had an accumulated stock pile of more than 25,000 tons of hog fuel and was faced with a very serious waste disposal problem. It was believed that the potential savings resulting from the use of hog fuel would be attractive to the University and that the conversion would aid the lumber company in developing new outlets for disposal of its refuse fuel.

A study was made of both the engineering and economic factors involved in the proposed steam plant conversion, and a report prepared setting forth, substantially, the following:

Hog fuel has been used for many years in the larger steam plants of the Coastal area of Oregon and Washington, including the Portland General Electric Company, Northwestern Electric Company, Eugene Water and Electric Board, and many state-owned institutions such as the University of Oregon, Oregon State College and the State Office Buildings at Salem, Oregon. In Missoula, the Montana Power Company was burning hog fuel at its city heating plant.

The experience of these large West Coast users of hog fuel indicated that the substitution of low cost hog fuel for more expensive coal and oil fuels was both feasible and economical in those areas where an adequate supply of hog fuel is available. An ample supply of hog fuel existed in the Missoula area, with relatively little commercial demand. Three large saw mills in or near Missoula, the Thornton Lumber Company, the Missoula White Pine Sash Company, and the Anaconda Copper Mining Company at Bonner were producing hog fuel.

[1] Presented at a meeting of the Inland Empire Section, Forest Products Research Society, July 16–17, 1954, in Missoula, Mont.

The Author: W. H. Rambo received B.S. in architectural engineering from U. of Oregon. He was employed in engineering departments of lumber, pulp and paper products, and woodwork manufacturers from 1920–1943. Since 1943 he has maintained his own consulting engineering office in Portland, Ore. Rambo has developed and holds patents on special machines for lumber manufacture, log barking, and hardboard production.

Composition of Hog Fuel

In any sawmill, approximately 30 per cent of the volume of the logs sawn is residue, sometimes regarded as waste material, in the form of sawdust, shavings, slabs, edgings, trim, and bark. To facilitate handling, storage, feeding and efficient combustion, all of this waste material, other than sawdust and shavings, must be fed through a hog which reduces the wood to chips or particles of small size which then may be conveniently conveyed. This chipped or shredded wood, together with varying percentages of sawdust and shavings, is "hog fuel".

Because of its bulky nature and varying moisture content, hog fuel is commonly purchased or sold by volume measurement, the accepted standard being the "unit", equivalent to 200 cubic feet as measured, without packing, in a truck or railroad car and weighing, at average moisture content, approximately two tons. The "unit" measurement derives from the fact that approximately 200 cubic feet of hog fuel is produced from one cord of wood. The average western sawmill produces slightly more than a unit of hog fuel for each 1,000 feet of logs sawn and will use approximately fifty per cent as fuel for its own steam production.

The heating value of hog fuel on a dry basis varies from 8,000 to 9,200 B.T.U. per pound, depending upon the kind of wood and the storage conditions. Studies of the depreciation of hog fuel in storage made by the Portland General Electric Company indicate that the loss of heating value per pound of dry wood is very slight, less than 6 per cent per year, although a considerable gain in moisture content may occur where open pile storage is used.

The moisture content of hog fuel (expressed as a percentage of total weight) may range from 15 per cent for hog fuel produced from commercially kiln dried wood to more than 65 per cent in residue from the "front" end of the sawmill, the average moisture content being between 45 and 50 per cent. For design purposes, it is ordinarily assumed that hog fuel, when burned, will produce 5,000 lbs. of steam per ton of hog fuel of this type.

Selection of Hog Fuel Burning Equipment

A number of factors are involved in the choice of the type of furnace to be used in the generation of steam from the burning of hog fuel. A first consideration is the maximum hourly steam capacity required, since each type of installation is best suited to a particular range of hourly capacity. A second is the importance attached to efficiency in the utilization of fuel.

Although efficiency may be of considerable importance to the commercial user of hog fuel, it is of lesser importance to the sawmill to whom hog fuel is regarded as a residue or waste material. Other considerations are the rapidity and amount of changes of load that must be anticipated, fly-ash emission that can be tolerated, and whether the installation can justify the cost of allied cinder recovery equipment.

Probably the oldest effective hog fuel burning furnace is the two stage Dutch-oven type installation, consisting of a primary furnace, or Dutch-oven, in which the fuel, deposited upon a flat grate in a conical pile, is dried and the volatiles and moisture content vaporized, and a secondary furnace in which combustion of the gaseous products is completed.

The primary furnace is lined with refractory material which, heated to incandescence by the burning fuel, supplies radiant and reflected heat to the surface of the fuel pile, maintaining combustion despite the periodic addition of fresh fuel to the surface of the pile.

At the point where the gases enter the secondary furnace, the roof or arch of the Dutch-oven slopes downward at an angle of approximately 45°. This drop nose arch has the dual purpose of radiating reflected heat upon the rear surface of the pile and, together with a bridge wall built up from below, providing a restriction that increases the velocity and directs the flow of gases entering the secondary furnace. Since combustion takes place at the surface of the fuel pile, probably 80 to 90 per cent of the air is supplied above the grates. Control of output is maintained by control of the volume of draft air supplied to the Dutch-oven and, to a lesser degree, by varying the distance between the fuel pile and the overhead arch.

The two battery-set three-drum 350 HP Union Iron Works boilers in the Montana State University steam plant were well suited for conversion to hog fuel burning. Since the University was greatly concerned that smoke and carry-over of fly-ash be held to a minimum, the Dutch-oven type installation with forced draft supplied from existing fans, was recommended.

It was calculated that the Union boilers, when converted to burn hog fuel, would have a maximum allowable output of 18,000 pounds of steam per hour each if operated at 173 per cent of rating. The University was burning coal costing $8.40 per ton and generating 13,127 pounds of steam per ton of coal burned, with a resulting steam fuel cost of $0.64 per thousand pounds.

Assuming from other experience that hog fuel would generate 10,000 pounds of steam per unit, or 5,000 pounds per ton, at the current Missoula market price of $1.75 per ton, it would produce steam at a fuel cost of but $0.35 per thousand pounds of steam, or at a saving of 45 per cent of the cost of generation with coal. Translated into terms of the then existing heating load, this offered a saving to the University of approximately $20,000 per year on fuel costs.

Additions and Modifications to Plant Facilities

Hog fuel, because of its lower calorific value and much lower density would require the provision of storage and conveying facilities capable of handling a much larger volume of material than that required for coal. Approximately 235 cubic feet of hog fuel is equivalent to one ton of coal occupying 42 cubic feet. On the other hand, ash disposal would become a very minor problem.

The required additions were made to the Montana State University steam plant in 1953. Providing for the storage, conveying and burning of hog fuel, they consisted of a large concrete and timber storage bin, having a maximum storage capacity of approximately 360 tons of hog fuel, a conveying system designed to convey fuel from the storage bin as required to the Dutch-ovens and to return unused fuel to the bin. Addition of Dutch-ovens to the boiler furnaces and necessary changes to the draft system were also made.

The fuel bin is of conventional design, a rectangular form approximately 30 feet by 50 feet in plan with sides sloping inward to an overhead conveyor gallery 12 feet wide located at a height of approximately 35 feet above ground. Special consideration was given to the appearance of the storage and conveying facility, the bin being so located as to be hidden by the steam plant building from the more important areas of the campus and trimmed and painted to blend with the existing building and surrounding landscape.

The main fuel conveyor is a bucket elevator conveyor having 20 inch square steel buckets spaced at 3-foot intervals, carried between two strands of 1½ by 6 inch round link chain. It runs on the centerline of the fuel bin, under the fuel bin and boilerhouse basement floor to the far end of the boilerhouse, rises vertically to the level of the boilerhouse trusses, returns over the Dutch-ovens, through the coal tower to the back of the fuel bin where it drops down a vertical shaft to complete the circuit under the fuel bin. A tunnel extends from the boilerhouse basement under the truck dump and fuel bin giving access to this conveyor at all points. This conveyor is driven by a two-speed

motor allowing the operator the choice of two conveying speeds.

Fuel is fed from storage in the fuel bin to the main bucket elevator fuel conveyor by a feeding conveyor of H-480 refuse chain located in the floor of the fuel bin directly over the main conveyor. The rate of feed of fuel from this conveyor to the bucket conveyor is controlled by a hinged weighted gate that limits the rate of feed to the amount of fuel that can be handled by the bucket conveyor when operating at low speed. A similar H–480 refuse chain conveyor, together with a regulating gate, is provided in the bottom of the truck dump, which is located in the paved area between the fuel bin and the boilerhouse.

One Dutch-oven cell is provided for each boiler, equipped with water-cooled grates measuring 8 foot 6 inches by 8 foot 6 inches. The existing air duct system was rebuilt to permit either or both of two existing forced draft fans to supply air to the Dutch-ovens. The existing automatic draft controls were reconnected and provided good regulation when forced draft is used.

Conclusions

Operating experience with the plant since its completion has fully justified the proposals originally advanced. Records for the period from January 1 to May 31, 1954, during which period steam was produced entirely from hog fuel, show the generation of 6,378 pounds of steam per ton of hog fuel, or at $1.75 per ton, a fuel cost of $0.27 per thousand pounds of steam. This represents a saving, when compared to coal, of 56 per cent of the fuel cost.

The fuel burned during this period was predominately spruce and an even better performance may be anticipated when burning pine, fir, or other species. The plant operates with almost no smoke and no carry-over of fly-ash. Some occasional manual labor is required in the fuel storage bin in breaking down stored fuel; however, this has not been a serious problem and, in general, has been less than was formerly required in the handling of coal. Ash removal labor has become almost negligible.

In summation, the cost of converting the Montana State University steam plant from coal to hog fuel was well in line with the anticipated fuel saving.

The Use of Small Cuttings in Manufacturing Millwork[1]

W. A. NORMAN

Carr, Adams & Collier Co., Dubuque, Iowa

Material formerly classified as waste is utilized in manufacturing doors, window units, and cabinets. Edge gluing, finger jointing, and laboratory testing of strength properties are described.

THE USE OF SMALL CUTTINGS is not new to this industry, since edge bonded material and core block material have been used for many years. However, considerable progress has been made in methods of gluing and in expanding the applications. The Carr, Adams & Collier Co., manufacturers of doors, window units, and cabinets, use raw material which is mainly ponderosa pine, purchased in shop grades, kiln dried, from the Northwest.

Edge bonding material, i.e., making wide boards out of narrow ones, has been done for many years on the so-called "merry-go-round" clamps. At this firm, this operation is now being performed on a 10 KW high frequency edge bonding unit using fortified urea glues. Edge bonded material is used in cabinet, door, and frame parts.

Core lay-up and bonding, making cores for flush doors, was done for many years in a hand operation on the merry-go-round clamps similar to the clamps which were used for edge gluing. This operation is now performed in a line set-up which cuts core blocks to length, joints, spreads glue, lays up and cures the core in a 10 KW high frequency unit. Urea glues are used on this operation.

End gluing with a finger joint is one of the newer operations in the plant. This makes long pieces out of short pieces. Machined pieces are pressed together and bonded with a melamine waterproof glue continuously in a high frequency tunnel. A 5 KW high frequency unit cures the glue as it moves through the tunnel. Finger jointed material is used in frame, cabinet, and some door parts.

Some background on the development of the finger joint in the operation might be of interest. Two principal properties of the joint, adequate durability and adequate strength, must be considered in judging its suitability for millwork use. Of these two properties we feel that durability is most important since if a waterproof resin glue is used, the strength of the piece with the finger joint will be more than adequate for the service strength requirements in most of our applications. In other words, the margin of safety, in terms of service strength requirement to actual strength, is more than necessary so long as the bond is more permanent than the wood itself.

With this waterproof requirement in mind, the first finger jointed material was glued with a resorcinol glue, a room temperature setting resin glue of the waterproof type. Original resorcinol resin glued members of ponderosa pine, untreated and not painted, have been on weathering racks for over six years. Aside from the discoloration and checking of the wood under these conditions, the joints are apparently unchanged. These specimens when pulled at the joint show complete wood failure, indicating that the glue is stronger than the wood itself.

Some objection was raised to the dark color of the resorcinol glue line and the curing time which necessitated considerable production space. So high frequency equipment was designed in cooperation with manufacturers, and in late 1947 the operation was changed to a high frequency melamine joint. This gives a light colored glue line and immediate cure. Tests on the weathering rack with melamine joints give the same indication as the resorcinol joints.

Considerable laboratory test work has been done on the strength of finger jointed material with the primary object of developing the maximum possible strength of the effective cross sectional area of the joint. Finger length must be adequate to develop shear

[1] Presented at a meeting of the Upper Mississippi Valley Section, FPRS, Nov. 2-3, 1954, in St. Paul, Minn.

The Author: Wayne A. Norman is a graduate of Iowa State College and was research and development engineer at the Air Corps' Materiel Command, Dayton, Ohio, during World War II. He joined Carr, Adams & Collier in 1946 as head of research, was named treasurer and assistant secretary in 1952, and recently became head of the production division.

strength sufficient to fail the effective cross sectional area at the base of the joint.

Compression strengths are comparable to clear unspliced pieces and the flexural strength is somewhat less than clear unspliced pieces. Finger length is adequate to develop a high percentage of the effective wood strength at the base of the joint end and, as pointed out under glues, gives complete wood failure.

In the interest of material conservation it is believed imperative that measures such as finger jointing be instituted when the service characteristics of the product are not affected. As indicated, both the strength and the durability of well-designed finger jointed members fabricated with a waterproof glue are entirely adequate for millwork applications. Edge bonded material is also entirely satisfactory when attention is given to the proper type glue for the application being considered.

One should not overlook the utilization of even smaller pieces than may be used by gluing methods outlined above. One use of small pieces, sawdust, and shavings is in wood particle boards. At this time the Carr, Adams & Collier Company is not manufacturing a wood particle board. All pieces not making core stock and below usable lengths are ground up in a hog, mixed with other sawdust and shaving waste, and then ground to a uniform 20 mesh and finer, to be sacked and sold for use in the plastics and roofing industry. Short lengths not usable in our industry, but not short enough to be considered waste, are bundled and sold to other industries.

In summary, narrow pieces are stretched into wider pieces by edge bonding, small pieces are formed into large pieces by core bonding, and short pieces are stretched into long pieces by finger jointing. These operations, combined with the marketing of unusable shorts and with the grinding of the remainder into wood flour, take care of all material formerly classed as waste.

Design and Planning of a Montana Sawmill[1]

E. C. WERT

President, Thompson Falls Lumber Co., Thompson Falls, Montana

Sawmill was designed after consideration of negative and positive factors involved. Lack of swamp room and lack of flow are common errors in many mills. Positive factors include production balance, economy, flexibility, construction costs, and fire control.

PRACTICALLY EVERY MILL OPERATOR can look at his sawmill and easily see basic errors in design or balance. There is no such thing as a perfect sawmill, nor will the perfect sawmill ever be built. However, every man has some specific ideas about what he considers to be the ideal layout for a new mill, but in most cases the individual is frustrated because he lacks the opportunity to put his ideas into practice.

This opportunity was presented to the management of the Thompson Falls Lumber Co. in the latter part of September, 1952, as the result of a fire that burned the sawmill to the ground.

In rebuilding, the operator has to consider the problem from a twofold approach. First, there is the negative, namely to avoid basic errors that exist in other mills familiar to the operator. Two of these errors are especially prevalent in mills of small and medium capacity. The first is lack of swamp room. Well over half of the sawmills in the Inland Empire are so cramped for space that it is impossible to obtain maximum labor efficiency for any prolonged period.

The second common error, which dovetails naturally with the first, is lack of flow. In watching the production of lumber in the average sawmill, the observer will notice that in most cases the lumber coming to the green chain comes in an inconsistent, sporadic manner. This lack of flow is a result of three things, generally: 1) lack of swamp room, 2) inadequate machinery, and 3) poor management. A smooth consistent lumber flow is of maximum importance because it is the foundation of manpower efficiency, and consequently of good sawmill practices and low sawing costs. There are other errors, but they are all reducible to the two mentioned—lack of swamp room and lack of flow.

The next approach the designer or builder of the new sawmill must consider is the positive. This amounts to nothing more nor less than this: what does he wish to accomplish with this new sawmill. First, he wants balance; the sawmill must produce the right amount of lumber for the mill's drying and planing facilities. Second, he wants economy—economy in labor and economy in maintenance. Third, the mill should be sufficiently flexible to allow for future changes in productive capacity. Fourth, finances must be considered.

As all readily appreciate, there is no such thing as a new way to saw logs into lumber. The basic process of sawing, edging, and trimming is the same in any mill in the Inland Empire. However, the combinations of machinery used and the placement of the same accounts for the differences seen in practically every sawmill. In this case, the machinery used throughout the mill is standard, and the combination of methods employed to break down a log has been used hundreds of times. The Thompson Falls mill is unique only in the placement of this machinery.

The sawmill is composed of three completely separate buildings. First is the bandmill, which is rectangular, 32 feet wide by 74 feet long. This building houses the deck saw, live deck, eight-foot, doublecut band mill, carriage, 14-inch shotgun, and 56 feet of track. There is a conventional slip and bull chain to bring logs to the deck.

The rolls from the band mill to the edger are approximately 140 feet long. This is because the building that houses the edger and trimmer is separated from the bandmill building by 96 feet. This edger-trimmer building is L-shaped and is 34 feet wide and 102 feet long, with a wing for a 24-foot trimmer that is 34 feet wide and 32 feet long.

The third building in the sawmill group is a gang building which is 24 feet wide and 48 feet long. The gang is a 25-inch oscillating type, built by the Dominion Bridge Co. The gang building is situated on a five-acre artificial pond and logs may be sawed by this gang as well as cants, if desired, since there is a side loader to deliver logs to the deck in the gang building. All three of these buildings and the rolls and floor chains connecting them have floors 16 feet above the ground.

There are ten employees in the sawmill, a grader, three pullers on the green chain, a millwright, and a filer.

[1] Presented at a meeting of the Inland Empire Section, FPRS, July 16-17, 1954, in Missoula, Mont.

The mill's capacity is about 55,000 feet per eight hours, with gross over-run about 16 per cent.

The flow of lumber is relatively simple. All logs are initially broken down on the headrig. The boards or pieces of dimension developed go straight to the edger by means of the long rolls and then to the trimmer and green chain. The cants for the gang also start away from the headrig on these same rolls, but some 30 feet out of the bandmill building the cants pass through an electric eye that activates a set of jump chains which carry the cants at right angles to the rolls up to an elevation of 7 feet above the floor.

From this point the cants break over onto gravity rolls that take them to the loaders for the gang. These gravity rolls are 80 feet in length.

The cants go through the gang and the lumber is carried on live rolls to automatically-activated arms which push the lumber at a right angle off the rolls and onto floor chains. These floor chains carry the lumber to an edger by-pass which is connected directly to the floor chains leading to the trimmer. If the lumber needs edging or ripping, it is carried over the by-pass to the edger. If it does not need edging or ripping, it is slipped edgeways into the by-pass. This by-pass is operated by a second edgerman.

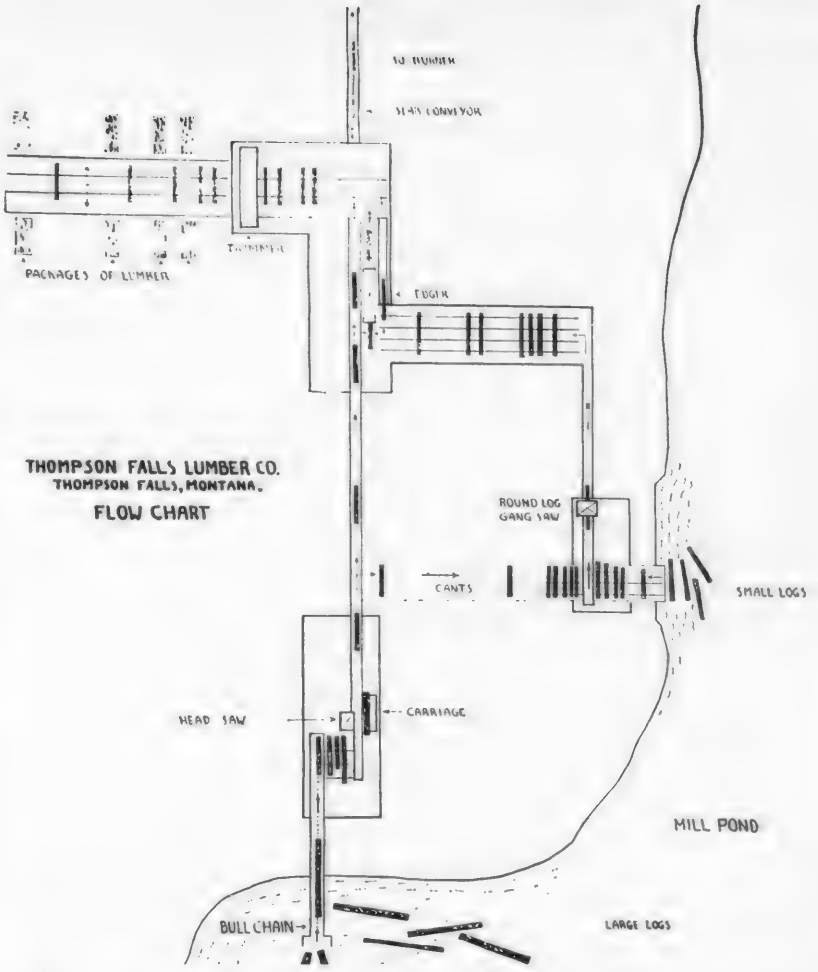
In these three buildings, there is a square footage of 8076′, exclusive of the 3300 square feet of floor space for the connecting rolls and floor chains. This is a tremendous amount of space for a sawmill with a rather modest cut.

Why was it built this way?

This goes right back to the approach adopted by the operator in considering the design of a new sawmill. What is wanted?

The first thing wanted was swamp room, and this mill has it. It is normal procedure for the mill to carry 2–3,000 feet of cants on the gravity rolls connecting the bandmill rolls with the gang. As much as 5,000 feet of cants can be stored on these rolls if wanted. On the floor chains connecting the gang with the edger by-pass, there normally is a working inventory of 1–2,000 feet of lumber and this can be increased to 3,500 if necessary. The floor chains leading to the trimmer carry a routine load of 5–7,000 feet of lumber. So it is average for the mill to have 4,600 feet in various stages of processing at any one time.

If the bandmill is shut down for a saw change, the gang as well as the back of the mill can continue to operate due to the cant storage. If the gang is down to change saws or to pick a shim, the band mill operates and the by-pass edgerman speeds up his work, drawing on the lumber storage built up from the gang. The flow of lumber through the trimmer and on the green chain remains relatively stable at all times.



A constant flow has enabled the mill to handle lumber with less manpower than would be necessary if it came to the green chain by fits and starts. An even flow of lumber is assisted throughout the whole sawmill by sorting logs into sizes and types, and alternating the logs as they are fed up the slip to the band mill.

What has been achieved in the line of balancing sawmill production with the rest of the operation? All the lumber can be cut that can possibly be dried and shipped with existing facilities, and still put no particular pressure on the sawyer and setter. The basic accepted procedures of correct sawing practices are strictly enforced. If a log must be turned five or six times to get the best recovery, the balance exists so that the sawyer may do this and neither production nor costs are affected materially.

One of the most important factors in the design of the Thompson Falls Lumber Company sawmill is its extreme flexibility in allowing for future expansion. As an example, if the firm should ever wish to substantially increase production, it would be a simple matter to install a fourth building housing a slab-horizontal re-saw with a merry-go-round. This could be done without causing any particular disturbance to present facilities, and the only lost-production time would be the few days necessary to tie in the chains or rolls leading to and from the resaw. There are also other additions to the sawmill that could be made while applying the same principles mentioned in relation to the resaw.

The fourth, and perhaps most important, positive factor incorporated in the design of the sawmill is that of fire control. Although it is completely sprinkled, there is still the possibility of a fire getting started under the right conditions in the mill. Chances of having a total fire loss have been reduced to a minimum by arranging the machinery in this spread-out manner.

Having combined all of these negative and positive factors important to sawmill design and planning into the mill, company officials are pleased with the result.

Around the World in Forest Products Research and Development by G. M. Hunt

Swedish Homes in Parcels[1]

LENNART BERGVALL
Home Building Research Corporation, Stockholm, Sweden

Swedish firm is prefabricating houses complete to the last coat of paint. Developments include process of gluing laminated boards in continuous band. Timber is utilized 100 per cent in mass production system.

BUILDING COSTS IN SWEDEN, as in most countries, steadily grew higher during and following World War II. Swedish industry accordingly had to pay increasing sums of money to make it possible for its workers to obtain homes.

Observing this development with anxiety, two of the larger Swedish industries, Uddeholms AB (lumber, pulp, paper, steel) and Skånska Cement AB (the leading Swedish cement manufacturer) found it necessary in 1944 to take steps in order to find methods for cheaper production of houses. These two companies started a special research corporation, AB Bostadsforskning (Home Building Research Corporation), with the purpose of finding new and cheaper ways to produce houses, especially for the workers and other employees of industry.

AB Bostadsforskning started its work in 1944, with little capital of its own, but generously supported by its sponsors. It was stated from the beginning that the aim of the company was pure technical and industrial research, the result of which should be made available to the entire Swedish industry. The fact that the two parent corporations were themselves producing a great number of building materials was not to have any influence upon the choice of material or construction.

Two architects with experience in standardization of building materials and in modular coordination, Lennart Bergvall and Erik Dahlberg, were appointed to carry out the research program.

In 1948 the research work had advanced so that a number of the larger Swedish industries joined the two parent corporations in forming a production company. The new company was to produce houses for the industry on the basis of the methods and inventions of AB Bostadsforskning.

These houses have now been in production for about two years. The price level, compared with traditional houses of equal size and quality and with equal equipment, will vary but generally they have come out about 15 per cent cheaper—as a result of technical research.

The system of prefabrication on which these figures are based is by no means the result of just a kind of wall construction or of any single detail. The results have been achieved by following these principles:

1) Rationalization work has included all or nearly all parts of the house and all steps of operation, such as factory production, storing, transport, and site erection.
2) Methods have been found and details designed to allow production of the parts on an industrial scale.
3) The parts are designed to allow a few standardized parts to be used for a great number, or nearly unlimited number, of different house designs (which in turn calls for a strict use of modular coordination).

Foundation and Basement: The system is based on the assumption that the foundation or basement is completed in the traditional manner before

[1] A contributed article.

Exterior of some of finished houses in north Sweden.

erection starts. The system lends itself equally well for houses with or without basements.

Structure: To allow industrial production and yet retain freedom in design walls, floors and ceilings are built of completely prefabricated sections of only 8-inch width and in lengths corresponding to room height and floor span respectively. Exterior wall sections and floor and ceiling sections have the same cross section with a thickness of 8 inches, while interior walls have the same cross section but with a smaller thickness, 4 inches. The thickness of the exterior walls is necessary due to the severe climate in some parts of Sweden.

The difficulties which might be expected from the great number of joints have been successfully overcome and the system lends itself extremely well for use in a more or less mechanical production line for the manufacture of panels. Furthermore, it is much easier to arrange for a continuous process of gluing, etc., if the panels to be produced are as narrow as 8 inches, than would be the case with panels of a width of 3–4 feet.

To insure exact dimension control, which is of basic importance in facilitating the erection of both the structure and the different kinds of equipment, the sections are built of wood material of comparatively good dimensional stability (cross-laminated wood and hard fibreboard). Furthermore, special steps are taken to have the panels erected in proper position.

The need of dimensional control has also lead to a *prefabricated chimney* construction, which allows the chimney to be erected without any bricklaying. A chimney in Sweden must allow the use of all kinds of fuel such as oil, coke, coal, and wood. Wood fuel especially, which often causes fires in the chimney, offers special technical problems.

Heat installation consists of a simplified one-pipe hot water system, specially designed to allow simple erection on the site of precut, bent, and threaded pipes and parts.

Other pipe and sanitary installation is usually applied on site, but the pipes and parts are precut, bent, and threaded. The bathroom installation, however, is nearly 100 per cent prefabricated. The bathroom floor consists of ordinary floor panels, on top of which is added a special watertight and prefabricated floor construction.

The electrical installation above the basement consists mainly of special wall and floor blocks with electric wiring and devices, such as switches or outlets, applied at the factory. These wired elements are connected at the site with a ribbon of wires which is applied behind a cornice. The ribbon is built at the factory with wires and connections ready, similar to the methods used in the automobile industry.

Dimensional Stability

Kitchen cabinets, wardrobes, and similar equipment are designed to insure dimensional stability, thus allowing them to be stored and shipped in flat pieces, which are assembled to complete units just before shipping.

As the erection on site of an ordinary house does not take more than about two weeks, it is extremely important that the erection work is not delayed by waiting for one or more missing parts. Therefore, practically all parts necessary to complete the houses are assembled in a store house at the factory and then shipped to the site in containers of 5 tons' capacity. The containers are loaded at the factory by the company's employees and unloaded at the site by the company's own erection crew.

At present it is not economical in Sweden in most cases to ship the containers directly from factory to site entirely by truck transport. A combined transport is usually preferred, so that the containers are loaded on railroad cars at the factory, later transferred at the railroad station to a 5-ton truck by using a special transferring device, and then taken to the site and unloaded. After the containers have been emptied, they are folded and sent back to the factory.

Erection is normally completed by a crew of four, which does not need to consist of skilled workers. However, at least one or two of the crew are specially trained by the company. All of the crew must be able and willing to take part in various jobs on the site, so that the crew works as a real team. An agreement with labor organizations on these problems has been reached. This has made it possible to overcome such difficulties as jurisdictional disputes—much against the prophecies of many builders.

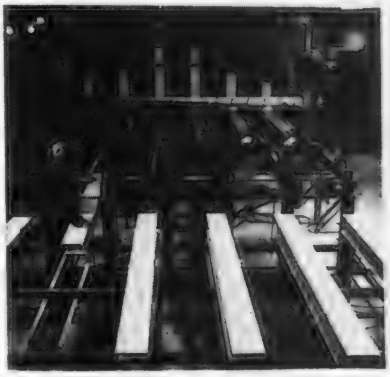
Special Plant

For the production of these houses, a special plant has been constructed in one of Sweden's timber districts. Besides the production of structure, carpentry, kitchen cabinets, etc., there is a shop for sheet steel work, a shop for preparing tubes and pipes of steel, cast-iron, and copper, and an electrical shop for wiring.

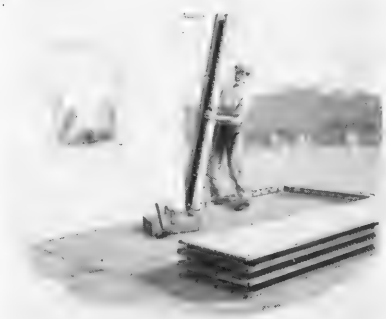
Since the product to be manufactured was entirely new, a special production process and special machinery had to be designed. Thus it has been possible to develop an industrial process where the timber is utilized 100 per cent. Timber not used in the laminated boards, in carpentry details, or as insulation in the form of compressed shavings is used to feed the steam boilers for the drying ovens. Some of the more interesting problems have been the development of a continuous process for gluing laminated boards, another for continuous gluing of the structural panels, a method for the storing of shavings and sawdust in silos, and a method for compressing the insulation in the panels.

The continuous gluing machinery may be of special interest to readers of the JOURNAL. As mentioned above, all the structural panels have a box-like

Press for automatic gluing of cross laminated boards fed in continuously.



Automatic filling of units with compressed shavings for insulation from lower silo in background. Large silo above feeds lower silo at intervals to avoid heavy pressure on filling screws.



Erection of exterior wall. Units are held in position by wooden dowels.

section with flanges of three-ply 3/4" x 8" cross laminated boards and webs of 1/8" hardboard. These panels are glued automatically so that first the laminated boards as well as the hardboard are glued together in endless, continuous bands. These are then joined together —with glue applied—to a box-like section with HF heating, planed to correct size, cut with a photo cell device to proper length, and thereafter sealed and filled with insulation.

The hardboard pieces are HF glued together with beveled edges. The laminated boards are built of a standard size of board, being approx. 1/4"x 4" after being planed ready for gluing. These boards—lengthwise as well as crosswise—are stored in magazines ahead of the press, and fed automatically into the press after the glue is applied. The press is of a special "clamp train" type instead of the "tractor belt" type previously tried in some other constructions. During the passage through the press with a speed of 20–30 feet a minute, the boards are fed with HF energy so the glue is cured. Both flanges are glued at the same time through the press (two levels).

It is obvious that the system described might be of value not only in Sweden but also in other countries such as the U.S.A. and Canada. However, situations in the building industry are different in various countries and therefore it would be necessary to modify the system and adapt it to different national conditions, both in technique and design.

During the years of research and development for this system, this company has had an opportunity to discuss problems on several occasions with the U.S. Forest Products Laboratory, Madison, Wis. They have also given valuable advice by correspondence. We are glad to have this opportunity to thank them for this broadminded cooperation over distance and borders, which we feel is so genuinely American.

REVIEW

Yield Study in the German Plywood Industry[1]

FRANZ KOLLMAN and HANS-JUERGEN SCHULTE-BRADER

THIS SUMMARY of a doctoral dissertation by a German student will be of interest to American veneer and plywood producers, because it gives yield figures and production losses for the various steps in the veneer and plywood manufacturing process. Over the years the impression has been created that the European veneer and plywood industry is very efficient in its utilization of logs, so that the waste factors would be relatively low.

This study covered 11 of the larger West German veneer and plywood plants. Data are given on beech and gaboon recoveries. Data for beech may serve for comparison with many of the hardwood species cut in the eastern part of the United States. The beech logs averaged about 18 inches in diameter and were cut to 5 1/2-inch cores.

Gaboon is a species brought in from Africa in large logs that are relatively free from defects. The average diameters were about 40 inches and core diameters averaged 7 inches. With respect to timber size and quality the gaboon cutting operation would be more nearly comparable to a softwood operation in the United States.

Recovery data, extracted from the report, can be summarized as shown in the table.

All percentage figures given in the tabulation are based on original volume of the log. The loss in processing could also be expressed as a percentage of the material entering the process under consideration. For example, the loss in panel trim sawing of beech is given as 4.8 per cent of the log volume. However, only 43.8 per cent of the log still remains in the form of plywood panels that come to the panel saws. In terms of this volume, the loss would be (4.8 ÷ 43.8) × 100, or about 11 per cent.

In making the above tabulation, the author did not include sanding as a manufacturing loss. Conventional sanding of plywood results in a reduction in volume of 5 to 15 per cent of the net plywood volume. End spurring at the lathe was not included, apparently because it is not practiced in Germany.

Comparable figures for American plywood production are not available for comparison. It is doubtful, however, that the losses in American plants would be any greater than those given above for German plywood plants.

H. O. FLEISCHER
U. S. Forest Products Laboratory

[1] Studien ueber die Ausbeute in der deutschen Sperrholzindustrie. *Holz als Roh- und Werkstoff* 12(12):465–471, Dec. 1954.

Step or process	BEECH: Loss in volume in processing Per cent	BEECH: Net volume remaining Per cent	GABOON: Loss in volume in processing Per cent	GABOON: Net volume remaining Per cent
Log delivered to mill		100		100
Crosscutting	5.8		4.2	
		94.2		95.8
Bark removal			7.0	
				88.8
Peeling, splits	1.8			
Peeling, core	12.8		4.0	
Peeling, roundings	6.8		8.2	
		72.8		76.6
Clipping	8.6		9.0	
		64.2		67.6
Drying (shrinkage)	8.4		5.0	
		55.8		62.6
Breakage, die cutting, and reclipping			4.2	
				58.4
Jointing	7.2		2.5	
		48.6		55.9
Hot pressing (loss in volume during pressing)	4.8		4.6	
		43.8		51.3
Panel trim sawing	4.8		)	
Cutting back rejects	1.5		)4.0	
Final plywood yield		37.5		47.3

Abstracts From Current World Literature

Properties of Wood

Saku, T. Relation between specific gravity and thermal conductivity of wood. *Wood Res., Kyoto* No. 9, 1952 (1–13). [Jap.e.]

Presents formulae for thermal conductivity in terms of dry density. [For. Abs. V. 15, No. 4]

Archihovskaja, N. V. Investigation of the moisture conductivity of wood. *Trud. Inst. Les.* 9, 1953 (127–57). [Russ.russ.]

Describes new methods of: (1) investigating the moisture conductivity of wood for a constant rate of moisture flow, and (2) determining the relative air humidity (r...) to an accuracy of ± 3% by measuring the moisture capacity of filter paper. Increase of the moisture flow rate is related to the gradual humidification of specimens; its decrease, to their drying. During the first 2 months, the moisture flow rate in specimens with a marked initial moisture content is considerably higher than in drier specimens; the difference disappears in the third month. When the r.h. on one side was 100%, the moisture flow rate was found to vary inversely as the r.h. on the other face. Moisture distribution curves in specimens are slightly convex up to 14–15% m.c., above this figure they straighten out or even become concave. [For. Abs. V. 15, No. 4]

Some influences of ultrasonic vibrations on wood. Part I. The effect of supersonics on improving treatability of wood. Report, Timber Engineering Co., Washington (Naval Research Contract N9onr87000) No. 1, [1949] (1–34).

Tests of treatable woods with vibrations of frequency range of 20–21 kilocycles and 1/10 KW power indicated a definite increase of free water flow due to the vibrational energy having no measurable pressure. In addition, there was a distinct persistence effect, the free water flow continuing for some time after the power had been turned off. The study of free water flow in resistant hardwoods has been limited to exploratory tests; these indicated that with the frequency range used the increase in free water flow was inappreciable. On the other hand, a definite acceleration in the rate of diffusion was found in some tests. The study to date has been limited to one narrow frequency range and by the low power density employed. [For. Abs. V. 15, No. 4]

Loe, J. A., and Mackney, A. W. Effect of age on density and moisture content of New Zealand *Pinus radiata*. Australian Pulp & Paper Ind., Tech. Assoc. Proc. 7:183–91; discussion. 191–4 (1953).

Results are presented to show variations in the basic density, green density, and moisture content in the stems of plantation-grown *Pinus radiata* trees whose ages varied from 24 to 40 years. Although no definite conclusions have been drawn, the results indicate that an increase in age results in an over-all rise in basic density and a decrease in moisture content. In sapwood, the green density attains a constant value of nearly 70 pounds/cu. ft. when the tree is approximately 30 years old. The study has been extended to include a preliminary examination of the interrelationship of various factors commonly associated with the presence of heartwood. [Bul. Pap. Chem. V. 25, No. 5]

Uganda timbers. Uganda Forest Department, Timber Leaflets Nos. 1–17, March 1954, Nos. 18–21, September 1954.

The first of these leaflets gives the properties of 49 Uganda timbers in tabular form, and also, for comparison, the properties of ash, hickory, redwood, oak and teak. The figures given include those for the weight per cu ft, the radial and tangential shrinkage, the bending strength, elasticity and the resistance to impact, compression, shear and splitting.

Timber leaflet No. 21 deals with building timbers. The list of woods suitable for cupboards and shelves may be of interest.

Information regarding supplies of the timbers described in the leaflets can be obtained from Uganda Timber Sales Ltd. [F.D.C. Tech. Bul. Vol. 4, No. 24]

Timbers of East Africa. Flatau, Dick and Co., 1954.

This booklet contains descriptions of 3 softwoods and 29 hardwoods which grow in East Africa. In each case the botanical and other names, the seasoning strength and working properties and the durability and uses of the timber are given as well as a description of its appearance. Most of the timbers are already well known in this country; some are used here mainly for flooring although they are found to be very satisfactory for furniture in Africa, and others which are used for furniture in Africa have never been imported despite apparently interesting properties.

The booklet has an index which includes the botanical, standard and common names of each timber and there is an extract from the Kenya grading rules. [F.D.C. Tech. Bul. V. 4, No. 24]

Glues and Gluing

Anon. Plastick thermo-setting veneering glue. Alfred Adams and Co., Ltd.

Plastick is a gap-filling modified animal glue which is mixed with a hardener and then applied cold. It is cured under contact pressure at a minimum temperature of 140° F. Higher temperatures shorten the setting time, e.g. for veneering 12 minutes is required at 160° F, but only 3 minutes at 212° F. When stored in airtight containers, Plastick can be kept indefinitely and after mixing with the hardener it has a pot life of at least 48 hours.

Some of the advantages claimed for this glue are that it gives a flexible and durable joint, cleaning equipment after use is easier than with synthetic adhesives, and there is no danger of dermatitis. Also, any blisters which occur during manufacture may be corrected by moistening and re-pressing. The cost and speed of set are roughly comparable with those for urea-formaldehyde resins. [F.D.C. Tech. Bul. V. 4, No. 24]

Jones, I. Electrical resistance heating for setting adhesives. Information Report, Technical Information Service, Furniture Development Council, London No. 8.

A survey of five methods. [For. Abs. V. 15, No. 4]

Veneer and Plywood

Anon. Xyl-o-pap flexible veneers. *Mikroholz GmbH,* Germany. Aga Trading Co., Ltd.

An interesting development in Germany has been the production of exceptionally thin rotary-cut veneers which are supplied mounted on a kraft paper backing. At present the veneers available in this country are birch and makore in a range of stained colors. They are supplied in rolls 19½ inches or 27½ inches wide and usually 50 yards long. The veneer is mounted on the paper using either animal glue or a synthetic adhesive. It is claimed that they can be finished by any of the usual finishing techniques.

The veneers have been extensively advertised in England for amateur use, but it is understood that in Germany they have also been used in furniture manufacture. The fact that they can be obtained in long lengths may warrant further investigation of their possible utilization for surfaces where severe wear would be unlikely. [F.D.C. Tech. Bul. V. 4, No. 24]

Sekhar, A. C. Elastic constants of plywood. *Comp. Wood* 1 (2), 1954 (32–7). 15 refs. P.R.

Results are graphed of experiments conducted by the method of free vibrations on 18 × 1 in. strips of commercial Birch.

The preparation of abstracts from world literature in many languages is so highly specialized and costly that the Forest Products Research Society has no abstracting service of its own. For the abstracts in this issue of the JOURNAL the Society is indebted to the respective abstract journals indicated, from which they have been selected with the kind permission of the editors. Readers wishing information in addition to that given in these abstracts should consult the original articles referred to. Copies or additional information can not be supplied by FPRS or the abstract journal. The journals from which abstracts are published in this issue are as follows:

BULLETIN OF THE INSTITUTE OF PAPER CHEMISTRY, published monthly at Appleton, Wisconsin by the Institute of Paper Chemistry, subscription price $25 per year. This Bulletin publishes over 3,600 abstracts per year on subjects of interest to manufacturers of pulp, paper, fiber board and allied products.

CHEMICAL ABSTRACTS, published semimonthly by the American Chemical Society, Executive Office—1155 Sixteenth Street, NW, Washington 6, D. C., subscription price $60 per year plus postage. This abstract journal publishes many thousands of abstracts annually with broad coverage of world literature in the entire field of chemistry and allied subjects.

FORESTRY ABSTRACTS, published quarterly by Commonwealth Agricultural Bureaux, Farnham, Royal, England, subscription price $8.40 per year. The abstracts are prepared by the Commonwealth Forestry Bureau, Oxford, England, and include a Forest Products and Utilization section. This section contains about 1,200 titles and abstracts per year from literature in some 30 languages, covers all aspects of forest utilization.

TECHNICAL BULLETIN OF THE FURNITURE DEVELOPMENT COUNCIL is published bimonthly by the Council at 11 Adelphi Terrace, London W. C. 2, England. The Technical Bulletin publishes hundreds of abstracts and reviews from world literature annually, relating to the various phases of the furniture manufacturing industry. Subscription price is $5 per year.

Maple, and Gaboon plywoods (with 3 or 5 plies and different thicknesses), the grain of the face veneer forming different angles with the longitudinal axis of the strip. The lengths chosen for Young's modulus and rigidity modulus were 40 cm. and 10 cm., respectively. It was found, *inter alia*, that the modulus of rigidity passes through a maximum when the angle between the grain and the axis of the test-pieces varies from 0 to 90°; this maximum had a greater value for 5-ply than for 3-ply wood. Experimentally determined mean values of Young's moduli agree fairly well with the calculated ones, the main deviation occurring at lower values of the moduli; the individual results of experiments are considerably scattered. [For. Abs. V. 15, No. 4]

Discoloration of knife-cut oak veneers. Forschungsinstitut für Sperrholz, Holzerzeugnisse und Holzleimung, Germany, Technical Report No. 2, 1954, p. 7 (in German).

Knife-cut oak veneers are often much darker on one side than the other when they come out of the drier. This is because one side is rougher than the other and more moisture escapes from it. The moisture carries tannin with it and deposits it on the surface where it oxidizes and causes the difference in colour. The discoloration is in the outermost cells and can be removed by scraping. Darkening can be prevented by correct steaming of the log. [F.D.C. Tech. Bul. V. 4, No. 24]

Milling

Horton, L. W., et al. Comparative time required to saw 1 M bf. from different log sizes. *Tech. Note Univ. Me. For. Dep.* No. 25, 1954. [For. Abs. V. 15, No. 4]

Thomas, D. P. Small band mill plus small logs equals increased lumber yield. Bull. Inst. For. Prod. Wash. No. 16, 1954.

A study was made of the conversion of 596 logs (average diameter 11 in. and length 16 ft.) in a small 5-ft. band mill with an average daily production of 30,000 bd. ft. The results gave an overrun of 39% above the net log scale. Labour requirements were 2.3 man-hours/1000 bd. ft. for a 9-man crew. [For. Abs. V. 15, No. 4]

Lumber Grading

Proceedings of a symposium on a standard hardwood quality index. Purdue Agricultural Experiment Station, Lafayette, Indiana. [1953]. pp. 85.

As a result of discussion it was agreed that the quality index [cf. *For. Abstr.* 15 (No. 1675)] of a log or tree should be calculated on the basis of: (1) No. 1 common timber grade, (2) one-in. thickness and (3) average timber prices for the period 1947–51. The following papers are included: The quality index concept (*A. M. Herrick*); The use of quality indexes in designing log grades (*O. P. Wallace*); The advantages of quality indexes in tree grading (*R. A. Campbell*); How the quality index can help in marking timber (*M. Martinelli, Jr.*); Quality index in evaluating sawmilling efficiency (*D. A. Kulp*); Historical and statistical stability in price ratios (*W. H. Cummings*); Lumber thickness and its effect on value and quality index (*C. L. Vaughn*); and A basis for hardwood log quality indexes (*P. R. Kramer*). [For. Abs. V. 15, No. 4]

Wood Preservation

Koljo, B. Effect of impregnation methods on the uptake of impregnant in wood impregnation. *Holz Roh- u. Werkstoff* 12 (1), 1954 (7–16). [G.g.] P.R.

Presents the results of tests on Pine (sap- and heartwood), Spruce, Birch and Oak (heartwood) impregnated with 1% $CuSO_4$ solution or creosote. The following methods were used. (1) pressure, (2) open-tank, (3) vacuum, and (4) Rüping. For H_2O the maximum uptake was obtained with (3) and (2), for creosote with (1) and for Birch and Pine sapwood, with the vacuum-pressure method. Different factors (time, pressure increase, temperature) have a relatively greater effect for species that are not easily impregnated than for those that are. For the former, full impregnation with aqueous solutions is best attained with (1) or the vacuum-pressure method; full impregnation of the latter with creosote can be attained by all methods. [For. Abs. V. 15, No. 4]

Penetrability studies [on Douglas Fir]. Rep. Pacif. Nthwest. For. Range Exp. Sta. 1953, 1954 (35–6).

Freshly felled Douglas-Fir saplings were cut into 4-ft. lengths and sprayed with a 3% solution of NaF in which *Trichoderma* spores were suspended, or with double-strength Dowicide G, or were left untreated. After several months, *Trichoderma* mould had developed profusely on all the poles save those sprayed with Dowicide G. Immersion in a petroleum oil showed that the oil penetrated ¼–½ in. into the mould-covered poles, but only ⅛ in. into the others. [For. Abs. V. 15, No. 4]

Seasoning

Kiln-drying lumber cut from young-growth Douglas Fir. Rep. Pacif. Nthwest. For. Range Exp. Sta. 1953, 1954 (54–5).

Preliminary results of a study indicate that sound-knotted timber from young-growth Douglas Fir can be kiln-dried to a moisture content of 12% and then satisfactorily surfaced without serious degrade. High-humidity kiln schedules are required. [For. Abs. V. 15, No. 4]

Ellwood, E. L., and Kauman, W. G. Project S. 7–12. Vapour drying. Progress report No. 3. Project P. 10–3. Pressure treatment of sleepers. Progress report No. 5. The vapour drying and preservation of Australian grown *Pinus radiata* railway sleepers. [First report.] Division of Forest Products, C.S.I.R.O., Melbourne. 1953.

The actual drying time necessary to ensure satisfactory creosote pressure treatment was ca. 5 hours for green sleepers using 'mineral turpentine' as the drying agent. Satisfactory creosoting was achieved by the Rueping process. [For. Abs. V. 15, No. 4]

Marketing

Lamb, F. B. Utilization, distribution and management of tropical American Mahogany. *Abstr. of thesis*, in *Dissert. Abstr.* 14 (4), 1954 (577–8). [University of Michigan.] O.R.S.

Reviews the history of the Mahogany trade, discusses the relationship between timber properties and uses, and studies ecological and silvicultural characteristics and management practices in relation to supply. [For. Abs. V. 15, No. 4]

Waste Utilization

Wild, Alfred. Review of some organic binders for use in structural clay products. Am. Ceram. Soc. Bull. 33, no. 12: 368–70 (Dec., 1954).

The various types of commercial binders available to the ceramic manufacturer are enumerated, including flours and starches, gums, alginates, alcohols and celluloses, wood extracts (spent sulfite liquor, lignosulfonates, and Palco sulfonates or redwood-bark derivatives), and miscellaneous, i.e., wax emulsions. No one type of binder can be said to excel for all types of clays, and the user must determine experimentally the best binder for his particular set of operating conditions. The physical results of various wood-extract binders in binding some clays are compared. [Bul. Pap. Chem. V. 25, No. 5]

Chipboard

Pungs, L., and Lamberts, K. Research on the use of R. F. heating in the manufacture of chipboards. *Holz Roh- u. Werkstoff* 12 (1), 1954 (20–5). 4 refs. [G.g.] P.R.

Results of tests on the variation in time of the process of hardening in relation to temperature increase and change of dielectric properties are given in graphs. The loss factor, equivalent resistance, dielectric constant and temperature have been determined as functions of time. R.F. treatment considerably reduces the time of hardening compared with the usual hot-plate method, particularly for the thicker boards. [For. Abs. V. 15, No. 4]

Barking

Can mechanical barking aid in northern hardwood utilization? *Paper Tr. J.* 138 (20), 1954 (104–5). P.R.

Presents operating details and a performance report of a pneumatic Andersson barker used for the barking of log-length hardwood. (Birch, Beech, Maple, and Oak) in a Massachusetts mill. [For. Abs. V. 15, No. 4]

Chemistry

Leopold, B. Recent lignin research in Sweden. *Pulp Paper Mag. Can.* 55 (3), 1954 (184–6). [For. Abs. V. 15, No. 4]

Pulp and Paper

Raw materials for more paper. I. Findings of an F. A. O. pulp and paper consultation, Rome, Italy, Dec. 1952. *Tappi* 37, No. 8 alternate pp., 14A–48A (1954).

A comprehensive global report dealing with coniferous and broadleaved woods and also nonwoody fibrous materials (I), the common pulping processes, suggested pulping processes for I, morphological and chemical properties of the various papermaking fibers, and the possible papermaking uses of tropical woods. Tabulated data but no references are given. [Chem. Abs. V. 48, No. 20]

Pathology

Roed, Hakon. Fungus damage to wood. Norsk Skogind. 8, no. 10:334–40 (Oct., 1954). [In Norwegian; English summary]

A survey of the causes and effects of the most common fungus damage is given, with special reference to wood decay. Following a brief account of the anatomical structure and the chemical composition of wood, the anatomy, nutrition, and dependence on environmental factors (temperature and moisture in particular) of fungi are discussed. For practical purposes, fungus deterioration of wood may be divided into three groups (molds, woodstaining fungi, and decay). The appearance and mechanical properties of wood damaged by these fungi are described, and the conditions under which they occur are briefly mentioned. [Bul. Pap. Chem. V. 25, No. 4]

Resources

Locke, E. G., and Johnson, K. G. Wood resources [of the East North Central States]. *Industr. Engng. Chem.* 46 (3), 1954 (478–83).

Tabulates the estimated annual amount of wood available for chemical industry in Wisconsin, Michigan, Minnesota, Illinois, Indiana, Ohio, Kentucky, and Missouri, and discusses the four primary chemical industries involved; pulping, wood distillation, wood extraction, and wood hydrolysis. [For. Ab. V. 15, No. 4]

Public Relations

Allen, B. E. Youth organizations are a part of our public. *Southern Pulp Paper Mfr.* 17, no. 12:74–7 (Dec., 1954).

The possibilities of 4–H clubs and forestry camps, free-seedling programs, scholarships in forestry schools, and mill tours for interesting young people in schools in the problems of forestry and in the pulp and paper industry are emphasized. All companies should be anxious for the youth in the states in which they operate to acquire in their formative years as much fundamental knowledge of good forestry management as possible and should assist in providing this knowledge to the best of their ability. [Bul. Pap. Chem. V. 25, No. 5]

Silviculture

Farrar, J. L., Gray, D. W., and Avery, D. Jackpine reproduction. *Pulp Paper Mag. Can.* 55, no. 12.136–8, 141–2, 145–6 (Nov., 1954).

In an effort to find a method to bring about jack pine reproduction, various types of logging, controlled burning, scarification with the Athens plow, and combinations of these methods were tried. In each case portions of the test areas were provided with additional direct seeding. It was found that the best stocking of jack pine seedlings resulted from the exposure of mineral soil by skidding logs in bunches followed by conventional logging and accompanied by lopping and scattering cone-bearing slash on the exposed soil. The use of the Athens plow following conventional logging and accompanied by lopping and scattering the slash gave almost as good results. Broadcast burning in early spring did not improve the results; direct seeding resulted in a fair crop of seedlings on the exposed patches of mineral soil, but not elsewhere. [Bul. Pap. Chem. V. 25, No. 5]

Staebler, George R. Planted hemlock shows good survival. Pulp & Paper 29, no. 1:106 (Jan., 1955).

Nursery-grown western hemlock planted in heavy brush and bracken in western Washington had a first-year survival of 90%. The planting is part of an experiment to test the ability of native conifer species to survive and grow under difficult site conditions; the encouraging results indicate that plantations can be successfully established with nursery-grown hemlock. [Bul. Pap. Chem. V. 25, No. 6]

Lyon, N. F. Silvicultural research in seeding and planting. Pulp Paper Mag. Can. 55, no. 11:158, 162 (Oct., 1954).

The author reports on the work which the Division of Research of the Ontario Department of Lands and Forests is conducting in the field of artificial regeneration techniques. Some of the problems being studied are the preferred spacing intervals, degree of root pruning, and duration of the planting period. [Bul. Pap. Chem. V. 25, No. 4]

Wood Drying Committee Newsletter

Kiln Stickers[1]

TO ONE NOT DIRECTLY ENGAGED in lumber handling, and indeed, to many who are, kiln sticks seem relatively insignificant and unimportant. At Kent-Coffey Manufacturing Company, Lenoir, N. C., kiln sticks are evaluated for insurance purposes in excess of $25,000. There is certainly nothing insignificant or unimportant in an investment of this amount.

Kiln sticks are also an item which must constantly be replaced because of loss through breakage and wear. Here, durability means a great deal and poor durability may cause a high cost of replacement which is not necessary. This report will not state definitely which species is best for kiln sticks since this can only be determined through a long-range program of accurate observation.

For a number of years, at Kent-Coffey we have been using a great number of thin sticks—sticks of ½ inch in thickness. We did not start this because we thought they were better than the usual ¾ inch stickers but because resawn crating stock was available at the time we needed kiln sticks.

It has long been recognized that air velocity has a great bearing on the rate at which lumber dries. When the conditioned air from the fans enters the load it is uniform in temperature and relative humidity. Because of this uniformity in the entering air, edges of the lumber dry at approximately the maximum rate. However, as the air travels through the spaces between the board surfaces, heat is used for evaporation, and moisture in the form of vapor is added to the air. This causes the passing air to become stratified with the lower temperatures and higher humidities next to the board surfaces. Any breaking up of this stratification by causing greater turbulence will result in greater efficiency in drying. Increasing the velocity of the air is one way to accomplish this.

By the use of thin stickers, the total air space between layers is decreased, thus increasing the air velocity. We did not have instruments to measure velocity but some years ago O. W. Torgeson of the Forest Products Laboratory ran an experiment of this nature and found that sticker thickness affected velocities as follows:

½ inch—454 feet per minute
¾ inch—389 feet per minute
1 inch—367 feet per minute
1¼ inch—330 feet per minute

From this comparison, it can be seen that as sticker thickness increases, velocity definitely decreases. This means that the drying rate also decreases.

To prove this, we set up an experiment by inserting two test boards, cut from the same piece of lumber, in the leaving-air side of two adjacent kiln trucks, one with ½ inch sticks, the other with ¾ inch sticks. The fans were set to circulate the air through the load without reversing, the air leaving always on the side where the tests were located. The boards were periodically weighed as accurately as possible and it was found that the board located in the truck with thin sticks lost moisture at a slightly faster rate, staying about .1 – .3 of a per cent lower in moisture content. At final weighing the thin sticker test board averaged .32 per cent lower in moisture content. However, these particular boards were from well air-dried stock (18 per cent M.C.) and the effect would be more pronounced in stock of a high M.C.

Perhaps even more important is the increase in kiln capacity gained by the use of thin sticks. We found at Kent-Coffey that ½ inch sticks gave us a 9.1 per cent increase in kiln capacity. This means that with our total kiln capacity our actual increase in kiln volume is about 35 M board feet or approximately 1 day's cutting for 3 cut-off saws.

However, there are also some objections to the use of thin sticks. One is that there is a greater entrance and frictional loss which causes an additional back pressure resulting in a slight increase in power consumption. However, in most cases this is almost negligible. Also there is undoubtedly a higher loss of sticks by breakage, at least when pine is the species used.

Cost is a highly variable factor. However, we found that our thin ½ inch stickers from southern pine were costing 9.16¢ each the way we were manufacturing them. The last sticks we made were from log run poplar, which was an accumulation of stock too thin to make 4/4. This had no inventory value so only the cost of labor was involved. This poplar made excellent sticks and yielded approximately 756 sticks per 1,000 feet.

From observation and experiments thus far, it is concluded that the results favor the use of ½ inch stickers mainly because of the increased kiln capacity. This increase in capacity, combined with the faster drying schedules, may be the answer to the great problem of kiln drying—that of meeting production requirements for dry lumber.

[1] Discussed by Percy Deverick at meeting of Southeastern Dry Kiln Club, April 23–24, 1954, at Asheville, N. C.

FPRS News-Digest, Continued

Benzon Elected by American Institute of Timber Construction

Frank B. Benzon, president and general manager of Timber Structures, Inc., Richmond, Calif., was elected president of the American Institute of Timber Construction at the recent annual meeting in San Francisco. George E. Schweitzer, general manager of Rilco Laminated Products, Inc., St. Paul, Minn., is the new vice-president and Frank J. Hanrahan was re-elected executive vice-president.

A technical education committee was appointed by President Benzon to undertake a long range program concerned with inclusion of engineered timber design in the broad picture of engineering and architectural education. "The designer today is freed from former controlling limitations by advancements such as stress-graded lumber, efficient fastenings, structural glued laminated lumber, and modern engineering know-how in timber design," Mr. Benzon pointed out.

Development of a proposed Inspection Manual for Glued Laminated Lumber by the AITC Inspections Committee was also reported. The manual, to be published shortly, will list steps recommended for performing shop inspection of glued laminated lumber to assure quality control.

TECO Producing Wood Truck Body for Army

Production of an advanced model all-wood military truck body has started at the laboratory of Timber Engineering Co., Washington, D. C., under contract with the U. S. Army's Ordnance Dept.

The new model will contain refinements in the basic design and fabrication principles used in producing the Type III solid lumber body, one of three Teco-developed models that were proven efficient during 14 months' testing at the Army's Aberdeen, Md., proving ground.

Design modifications will lighten the truck body's weight, simplify and facilitate field repairs, and reduce mass production costs. The one-piece, U-shaped, laminated veneer frame members used in earlier models will be retained as one of the key strength factors, particularly in the curved section where sides and floor join. Solid lumber, however, will be used in the bottom section.

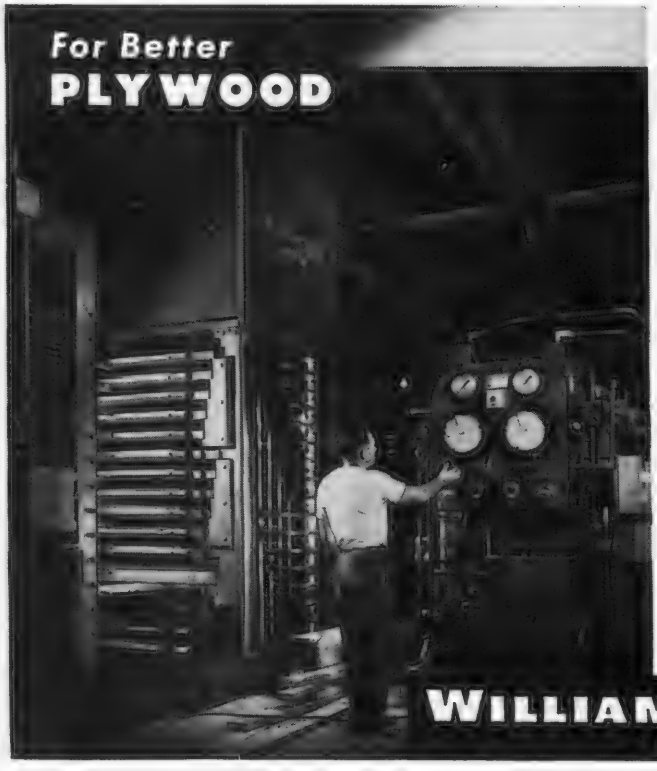
AFPI Advertising Mat Series Available to Industries, Media

"The Wood In Your Life" is the title of the 1955 forestry advertising mat series being offered to newspapers, magazines, and industries without charge by American Forest Products Industries. This year's series, 15th offered by AFPI, consists of 20 three-column x 10-inch and 6 two-column x 7-inch display ads ready for use. The individual ads range from do-it-yourself promotion and uses of pulp and paper to multiple use aspects of tree farming.

Copies of the AFPI Forestry Ad Proof Book are available from American Forest Products Industries, Inc., 1816 N. Street N.W., Washington 6, D. C. Each proof book contains a postage-paid order card for individual ads.

California Needs Teachers

Forest industries, the Redwood Region Conservation Council, and the Western Pine Assoc. have stimulated a demand for high school teachers in California to handle vocational and general education courses in forestry and conservation. Inquiries about the openings should be sent to the Redwood Region Conservation Council, 567 Sacramento St., San Francisco 11.



All WILLIAMS-WHITE
HOT PLATE PRESSES
are Truly Custom Built

Perfect plywood requires exacting control of pressure and temperature and a rigid frame section. These are basic in WILLIAMS-WHITE Hot Plate Presses.

See our representative nearest you or write us direct for full information. No obligation on your part, of course.

Representatives:

ALLIED NORTHWEST MACHINE TOOL CORP.
Portland, Oregon

WILLIAMS–WHITE & CO., Chicago Office
J. E. Maynard, Manager
53 West Jackson Boulevard

WILLIAMS-WHITE & Co.
MOLINE, ILLINOIS

NAMES IN THE NEWS

Vaux, Dickinson Named to California University Posts

Henry J. Vaux has been named Dean of the University of California School of Forestry. He joined the University faculty in 1948 as lecturer in forestry, after transferring from the California Forest and Range Experiment Station, Berkeley.

F. E. DICKINSON

Fred E. Dickinson, Chairman of the Dept. of Wood Technology, U. of Michigan, has accepted appointment as Head of the Forest Products Laboratory, U. of California, Berkeley. Dr. Dickinson was formerly on the faculty of the School of Forestry, Yale University, and was associated with the U. S. Forest Products Laboratory, and wood products industries in the Lake States, California, Northeast, and the South.

Both appointments are effective July 1.

Nichols Heads Plywood Institute

D. E. Nichols, president of Valdosta (Ga.) Plywoods, Inc., has been named president of Hardwood Plywood Institute, Chicago. New vice-president is Robert Beggs, executive vice-president of Roddis Plywood Co., Marshfield, Wis.

J. P. Weyerhaeuser, Jr. Named To Stanford Institute Board

J. P. Weyerhaeuser, Jr., president of Weyerhaeuser Timber Co., Tacoma, Wash., has been named a director of the Stanford Research Institute, Stanford, Calif.

Kemp Heads Texas Dept.

Arne K. Kemp has been appointed Head of the Department of Forestry, Stephen F. Austin College, Nacogdoches, Texas.

Truman Collins Heads Forest Industries Council

Truman Collins of Collins Pine Co., Portland, Ore., has been elected chairman of the Forest Industries Council. Deputy chairman is Stuart B. Copeland, Northwest Paper Co., Cloquet, Minn., and secretary is T. H. Mullen, American Paper and Pulp Assoc. and American Pulpwood Assoc., Washington, D. C.

FPRS News-Digest, Continued

W. W. Crittenden Joins Staff of Sawmill Machinery Manufacturers

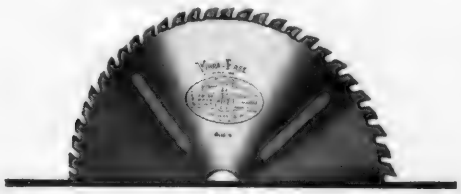
William W. Crittenden has joined the Prescott Co., Menominee, Mich., as vice-president and general manager. Crittenden was associated with Westinghouse Electric International Co. for 25 years.

Appointment of Henry F. Horton as vice-president of sales was also announced by the Michigan firm. Horton is a recognized authority on the installation and operation of sawmill machinery.

Conway Heads Utilization Study

Errett M. Conway recently was transferred to the Athens-Macon Research Center of the U. S. Forest Service and now heads a program concerned with effective utilization of upland hardwoods of the Piedmont area.

A FPRS member, Conway holds B.S.F. and M.F. degrees from the University of Michigan and worked on the Ohio Farm Woods Survey program from 1939–41. He served with TVA at Norris, Tenn., from 1941 until his recent transfer, with the exception of three years' service in the U. S. Navy during World War II.



A REVOLUTIONARY DEVELOPMENT

VIBRA-FREE*

CARBIDE TIPPED

MEYCO SAWS

You will be interested in this radically new development IF your carbide tipped saws sound like a police siren; IF they develop a "snaky" cut after short usage; IF they dull fast because carbide tips become chipped.

MEYCO VIBRA-FREE* saws embody a new principle in saw design, a new control over vibration by the use of sound absorbing dampers, which eliminate excessive vibration, excessive noise . . . produce smoother cuts, longer life for carbide tips. You get MORE cuts between sharpenings and operators LIKE to use Vibra-Free* blades. Investigate this revolutionary development TODAY. Write for Catalog No. 24.

*T. M. Reg. U. S. Pat. Off.

W. E. MEYERS CO., INC., BEDFORD, INDIANA

"MANUFACTURERS OF PROCESSING MACHINES SINCE 1885"

GRUENDLER EQUIPPED, TYPICAL WOOD WASTE OPERATION

WOOD WASTE

Pine, Hickory, Cedar, Elm, Oak, Gum, Walnut, including Knots, Barks, Waste Veneers

Ground to Sawdust and to Wood Flour

There's PROFIT in By-Products made from processed wood wastes. Markets are expanding, and Gruendler Processing Machines are showing the way.

WRITE FOR MORE DATA AND ILLUSTRATED BULLETINS

GRUENDLER

CRUSHER & PULVERIZER CO.

2915 North Market Dept. FP-4 St. Louis 6, Mo.

FPRS News-Digest, Continued

NEW PUBLICATIONS

Nemaho, N. V. Nemaho, Doetinchem, Holland. Illustrated catalogue of examples of several types of laminated timber structures.

Distribution of Concentrated Loads by Laminated Timber Slabs. W. C. Huntington, W. A. Oliver, M. W. Jackson, and W. T. Cox. University of Illinois Engineering Experiment Station Bull. 424. $1. Results of study of 119 laminated timber slabs. Variables considered were type of fasteners and their location in lamination. span length, number of laminations in the slab, material used, number of laminations to which load was applied, and effect of repeated loads. Conclusion was reached that important factor in distribution of concentrated loads among laminations of a slab is the type and arrangement of fasteners, and that wood species used is of small importance.

Effectiveness of the L-Shaped Fence Staple. E. George Stern. Virginia Polytechnic Institute. Wood Research Laboratory Bull. No. 17.

Photo-Interpretation Aids. Clarence D. Chase and S. H. Spurr. Misc. Report 38, Lake States Forest Experiment Station, St. Paul, Minn. Lists more than 100 aids to interpretation of aerial photographs. The list provides a brief description of each device and its use, indicates where obtainable, and the price.

Effects of Corn Silage Liquor on Two Wood Preservatives. C. S. Walters. Forestry Note 54. Illinois Agricultural Experiment Station, Urbana, Ill.

Preservative Treatment of Fence Posts by Cold-Soaking in Pentachlorophenol-Fuel Oil Solutions. C. S. Walters. Forestry Note 55. Illinois Agricultural Experiment Station, Urbana, Ill.

Preliminary Wood Preservation Statistics. 1954. U. S. Forest Service, Washington 25, D. C.

Forest Research in California. 1954 annual report, California Forest and Range Experiment Station, Berkeley 1, Calif.

The following publications are available from the U. S. Forest Products Laboratory, Madison, Wis.

Effect of Oven Heating and Hot Pressing on Strength Properties of Wood. J. D. MacLean. Preprint, American Wood Preservers Assoc. Annual Meeting, St. Louis, Mo., April 13–15, 1955. Third paper discussing results of experiments started at FPL several years ago to study effect of different heating mediums, different temperatures, and different heating periods on strength properties of representative hardwood and softwood species.

Evaluating Wood Preservatives by Soil-Block Tests: 8. Low-Temperature Coal-Tar Creosote. Catherine G. Duncan. Preprint, A.W.P.A. Annual Meeting, St. Louis, Mo., April 13–15, 1955. Evaluation of the relative effectiveness against decay of two low-temperature coal-tar creosotes before and after permanence tests. Comparison was also made between these and a high-temperature coal-tar creosote.

Some Experiences of the Forest Service with Treated Wood. J. O. Blew, Jr. Preprint, A.W.P.A. Annual Meeting, St. Louis, Mo., April 13–15, 1955. The requirements and policy of the Forest Service with regard to treated wood are discussed. Information is presented on the use of treated wood in two regions and service records on treated towers and bridges under contrasting climatic conditions in the Southern and Intermountain region are included.

List of Publications on the Growth, Structure, and Identification of Wood. No. 177. March 1955.

TURN WOOD WASTE INTO PROFITS with a Consolidated Baling Press

Package and sell shavings, fibers and chips to paper mills—hardboard and molded product makers—poultry and dairy farmers—nurserymen and florists—others.

DUPLEX Double Chamber Hydraulic Press
Loads and Compresses Simultaneously
- The DUPLEX will produce over 35 bales (100 lbs. each) per hour.
- These bales are small and dense for lowest shipping and handling costs.
- Hydraulic presses assure lowest operating and maintenance costs.

Proper packaging means baling to insure uniformity of material and low costs. CONSOLIDATED hydraulic baling presses give you speedy, low-cost baling of your shavings, fibers and chips, converting waste products into extra income. There is a CONSOLIDATED press to fit your needs.
Write for full details and catalog.

CONSOLIDATED BALING MACHINE COMPANY
Sales Division of
N. J. Cavagnaro & Sons Machine Corp.
400-404 Third Avenue Brooklyn 15, New York

If you have a Quality Control Conscience and a Moisture Control Problem

Then we hope that while you are in Seattle attending the FPRS National Convention you'll find time to visit the home of Laucks SENTRY® . . . It is the only high speed continuous moisture detector to incorporate ALL features necessary for 100% control and is used nationally in more than 100 applications ranging from rough lumber to the finest paper.

Please telephone us for a plant visit.

LAUCKS LABORATORIES, INC.
1201 Poplar Place Seattle 44, Washington
LEADERS IN WOOD TECHNOLOGY FOR 47 YEARS

FPRS News-Digest, Continued

NEW PRODUCTS—LITERATURE

New Refuse Burners

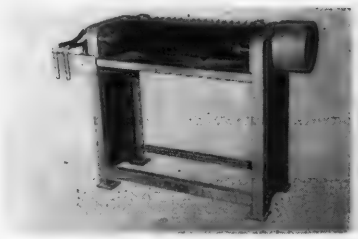
Redesign of the Wilco refuse burner and addition of a new "Junior" model for small woodworking operations is announced by Wilco Machine Works, Inc.

Improvements reported include a new inner liner giving more protection, simplified dome and syphon draft construction for easier erection, and new forced draft system giving twice as much capacity plus variable control. The manufacturer also announced it is prepared to supply dust collectors, supports, conveyor hoods, chutes, and other auxiliary equipment with the burners.

A bulletin containing basic specifications and a chart for selecting the proper size refuse burner is available from the Wilco Machine Works, Inc., 1301 N. Hollywood, Memphis, Tenn.

Glue Spreader

A modified glue spreader, designed for edge gluing lumber stock or other special applications which call for bottom coating only, is being manufactured by Black Brothers, Co., Mendota, Ill.



The new "Bob Tail" model is reported to contain essential features for economical application of fast setting resin adhesives. These include a drip-proof glue reservoir plus a resilient gluing roll which conforms to stock irregularities and spreads a properly controlled glue line. A water cooled doctor roll for use with glues with extremely short pot life at room temperature is available as optional equipment.

Humidity Control Bulletin

Facts about losses caused by dry air during the heating season are discussed in a 16 page humidification control bulletin available from Armstrong Machine Works, Three Rivers, Mich.

The bulletin, No. 500, gives details of the effects of relative humidity on profits, hygroscopic materials, health, dust, and static electricity. Tables show recommended relative humidities for processing and storage of various hygroscopic materials and effect of indoor heating on per cent RH.

Wood Repair Color Card

Publication of a color card of a paste wood-filler called Wood Repair, showing 12 popular wood shades and white, is announced by National Casein Co., 601 West 80th St., Chicago 20. Copies of the card, W R–70, are available on request.

The putty is in ready-to-use paste form for repairing cavities, splits, and checks in wood. It reportedly takes

PROFESSIONAL CARD

W. H. RAMBO
INDUSTRIAL PLANT ENGINEER
Specialist in
Furniture & Woodworking Plants
Sawmills, Veneer Plants
Paper Mill Wood Rooms
Hard Board Plants & Wood Preserving Plants
Design, Supervision of Construction
Reports & Surveys
Loyalty Bldg. Portland 4, Ore.

Complete Service On Wood Preservatives!

TECHNICAL COUNSEL
A full staff of specialists with years of experience and complete laboratory facilities, ready to assist in every way.

ENGINEERING SERVICE
An experienced engineering department to help in planning, designing and installing new pressure-treating plants; modernizing old plants; selecting equipment to meet your specific needs.

WOODTOX Penta Preservative and Water Repellent
A clear, clean, non-staining treatment combining advantages of Penta plus resistance against swelling, warping, shrinking and other moisture damage. Meets NWMA and Western Pine Assoc. preservative standards.

PENTAchlorophenol WOOD PRESERVATIVES
Most satisfactory and permanent of all wood preservatives against decay, fungi, termites and other wood boring insects.

NOXTANE SAP STAIN CONTROL
Most effective, safe and economical treatment made for protection against sap stain fungi. Leaves wood bright and clear. Quick solubility, dustless, non-irritating. Won't damage metal equipment.

EQUIPMENT
Exclusive national sales agents for Efurd Machine & Welding Company, builders of Hurricane Debarkers, Peelers, Framers, Incisors, Trams, etc.

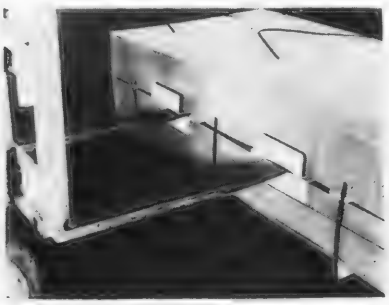
Whatever your problem in the protection and preservation of forest products, this is where you can always get the *right answers quick!* Write or phone.

WOOD TREATING

WOOD TREATING CHEMICALS CO.
5137 Southwest Avenue St. Louis 10, Missouri

FPRS News-Digest, Continued

stains and finishes under most conditions. The manufacturer states that Wood Repair is easily sanded and machined, and has a minimum amount of shrinkage.



Increased Handling Efficiency

Material handling efficiency was increased in the warehouse dept. of the Masonite Corp. plant at Laurel, Miss., through design of "easy entry plates" in steel-strapped bundles of hardboard.

The 3,000-pound bundles are divided into two or three sections by 1″ x 4″ x 4′ separators before bundling with Signode steel strapping. Because the 1″ opening would not accommodate the forks of lift trucks, Masonite developed an entry plate which permits insertion of the forks without damaging the edges or surface of the hardboards.

The entry plates can be made at low cost by local sheet metal shops, and are adaptable to other handling problems. A detailed print of the entire operation, including a plan for making the easy entry plates, is available from the Signode Steel Strapping Co., 2600 N. Western Ave., Chicago 47, Ill.

Woodworking Manual

The second edition of "Knife Grinding and Woodworking Manual" was published recently. Copies are available from the author, C. G. Monnett, Jr., vice-president, Dependable Machine Co., Greensboro, N. C. Price of the book is $4.50 plus $.50 postage and handling fee.

Subjects covered in the manual include: grinding and setting knives, moulder operations, balancing knives, composition and care of grinding wheels, jointing knives, development, selection, and care of cutterheads and knives, cutting angles and bevels, cutting speed, feed speed, energy consumption in machining wood, moulder and planer machine stoppages and their remedies, structure of wood, lumber abbreviations,

Machine Saws Sheet Plastic

Four to six school desk tops are being cut from a laminated plastic sheet stock in 40 seconds, it is reported by American Seating Co., Grand Rapids, Mich. The machine being used is a Mereen–Johnson 435 H multiple cut-off saw with variable speed chain feed.

The desk top material is multiple ply melamine and phenolic resin impregnated kraft paper with a hardboard core. Sheets 4 by 8 feet are run through the saw twice. On the first run, the sheet is cut into several strips. On the second, the strips are cut laterally into rectangular desk top blanks.

Two men feed the saw by placing one or several stacked sheets on the chain feed. After the material has passed through on the first cutting, it falls onto a roller conveyor which carries the blanks back to the operator for the final cut.

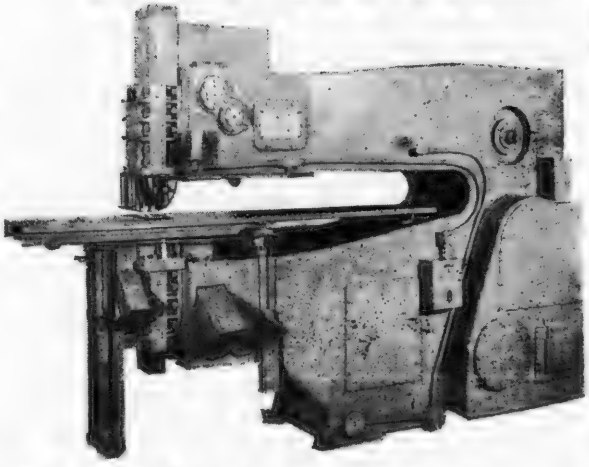
SKOOG

VENEER PATCHERS

FOR FACES & BACKS

SKOOG Patcher Type OB is recommended for faces and backs. This is a precision tool manufactured to do a precision job. This type can be equipped with either round or elliptical dies.—For general patching we recommend Skoog Type R . . . a fast, simple operation proven by many years' use.

WRITE TODAY FOR SPECIFICATIONS



SKOOG ENGINEERING CO.

P. O. Box 102 Olympia, Washington

Power Saw Safety Guard

Manufacture of a new type safety guard for power saws is announced by Latt–Guard Co., Englewood, N. J. The company claims the device affords complete protection in the operation of any conventional table.

The guard consists of a cast aluminum standard and transparent plexiglass shield which allows full vision in a wide variety of cutting operations. Having three operating positions, the guard is also designed to be used as an over-riding fence in angular work.

FPRS SCOREBOARD

by Bob Smith

The leading Sections in the membership drive contest will receive awards at the Ninth National Meeting in Seattle this month.

As of April 29, the leading Sections in membership growth (percentagewise) were the Inland Empire Section, the Northern California Section, and the Eastern Canadian Section. Credit goes to Tony Veazey, Victor Roth, and H. Sterling Maxwell for conducting enthusiastic, successful campaigns.

New membership chairmen have been appointed for a number of Sections. If you wish to receive help or promotional materials for use in contacting prospective members, please get in touch with your Section membership representative: Carolinas–Chesapeake, R. I. Quigley, The Lilly Co., High Point, N. C.; Eastern Canadian, George Roy, Plywood Associates, Inc., Box 290, Ste. Rose (Laval), P. Q., Canada; Florida–Georgia–Alabama, Dr. Jacob Huffman, School of Forestry, U. of Florida, Gainesville, Fla.; Great Lakes, Harold D. Sprunger, Dunbar Furniture Corp. of Indiana, 417 W. Water St., Berne, Ind.; Inland Empire, Tony S. Veazey, Anaconda Copper Mining Co., 10 E. Quartz St., Butte, Mont.; Mid-South, James F. Haskins, 4806 Woodmont Dr., Jackson, Miss.; Midwest, Vern Bergquist, Reichhold Chemical Co., 7738 W. 61st St., Argo, Ill.; Northern California, Victor H. Roth, Triangle Lumber Co., 610 Sixteenth St., Oakland 12, Calif.; Northeast, Paul H. Graham, Clinic of Wood, Box 105, Newfane, Vt.; Ohio Valley, Carl Seng, Jasper Desk Co., P. O. Box 111, Jasper, Ind.; Pacific Southwest, Axel V. Pedersen, 3631 W. Vernon Ave., Los Angeles 8, Calif.; Pacific Northwest, Earl T. McCarthy, American Marietta Co., 3400 13th Ave. S. W., Seattle 4, Wash.; and Upper Mississippi, Howard Olson, Chapman Chemical Co., 3 Hunter Lane, St. Paul, Minn.

In the month of April the Society gained 48 new members. However, 42 persons discontinued their membership after the first dues invoicing. Total memberships in the Society after discontinuing these men came to 2,734. Subscriptions to libraries added up to 130, raising the grand total of FPRS memberships and subscriptions to 2,864.

	Members 1953	Members 4/29/55	Wgtd. Avg.
Inland Emp.	44	73	.573
No. Calif.	93	136	.425
East Canada	129	176	.339
Great Lakes	167	218	.290
Northeast	405	514	.267
Pac. N'west	299	377	.253
Upper Miss.	80	97	.189
Fla.–Ga.–Ala.	86	103	.179
Mid-South	140	163	.154
Ohio Valley	82	95	.143
Car.–Ches.	204	234	.143
Pac. S'west	48	54	.110
Midwest	306	334	.090
Foreign	193	160	---
Totals	2,276	2,734	.225

SURE WAY TO STOP CHIGGERS & TICKS!

Repels and kills these tormenting, disease-causing insects—also mosquitoes, black flies, other infectuous pests. Help prevent Rocky Mountain Spotted Fever, Tick Fever, etc. Used by U. S. and State forestry and wildlife depts., logging firms, etc. A few second misting on clothing protects all day!

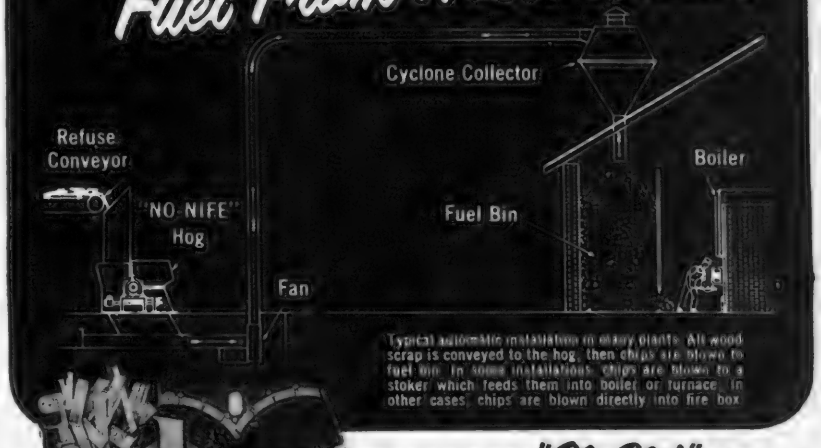
MINE SAFETY APPLIANCES CO.

54 Branches Everywhere

Home Office: Pittsburgh 8, Pa.

America's No. 1 Spray-On Insect Repellent!

Get Better, Lower-Cost Fuel From Waste Wood!



Typical automatic installation in many plants. All wood scrap is conveyed to the hog, then chips are blown to fuel bin. In some installations, chips are blown to a stoker which feeds them into boiler or furnace. In other cases, chips are blown directly into fire box.

Cross section of "No-Nife" Hog showing how fast-moving chisel-edge hammer reduces wood by impact until properly sized to pass through grates in bottom of hog.

WILLIAMS "No-Nife" HOGS

When reduced to chips in a "No-Nife" Hog, wood scrap is 100% combustible—the cheapest of any fuel for producing heat and power. Money-wasting unhogged wood refuse won't burn evenly, restricts air flow, smothers the fire, causes excessive smoke and soot.

By hogging, handling costs are also reduced up to 75%. One man can handle as much tonnage in chip form as three men can handle in long lengths, awkward and odd-shaped pieces. In most installations, labor savings alone pays for a "No-Nife" Hog in a few months.

Williams builds a complete line: Hogs, Grinders & Shredders • Vibrating Screens • Air & Mechanical Separators Heavy Duty Fans • Cyclone Collectors.

WILLIAMS PATENT CRUSHER & PULVERIZER CO.
2714 N. 9th ST., St. Louis 6, Mo.

Write For Fact-Filled Brochure

WILLIAMS

CRUSHERS GRINDERS SHREDDERS

OLDEST AND LARGEST MANUFACTURER OF HAMMER MILLS IN THE WORLD

NOW—You Can Cut Steam Radiation Losses 50%!

● Install STANDARD PREFABRICATED DRY KILNS! That's what the Toledo, Ohio plant of Jennison-Wright Corporation did recently. Their STANDARD PREFABRICATED DRY KILN . . . featuring cross-circulating, direct-driven fan units housed in a sturdily-constructed building of rust-proof aluminum panels . . . has a 2″ side wall insulating core equivalent to the insulating value of 27″ of common brick, and a 3″ roof core equivalent to 41″! *Compared with a good masonry building, steam radiation losses are reduced 50% or more . . . resulting in tremendous fuel cost savings!*

STANDARD PREFABRICATED DRY KILN installed at Jennison-Wright is 26′ wide x 40′ long x 18′ high. It's of the end-piling type, and is designed for package loading. It requires little maintenance, and can be easily moved and re-erected at a different site whenever desired.

This is an inside view of the kiln's operating room. It's located over the kiln at the discharge end. Notice **STANDARD'S** compact and easily-installed automatic control panel.

Decide now to cut steam radiation losses, and insure uniform drying of all your wood products. STANDARD PREFABRICATED DRY KILNS can be *completely* installed in any size—from a small research kiln to a large production unit—in only a few days!

Write for free, illustrated Standard Catalog

Manufacturers of Internal Fan Kilns

STANDARD
Engineers and Manufacturers Since 1887
DRY KILN COMPANY

P. O. BOX 5708....INDIANAPOLIS 21, IND.

BRANCH OFFICE: REDMAN ENGINEERING SERVICE • HIGH POINT, N. C.

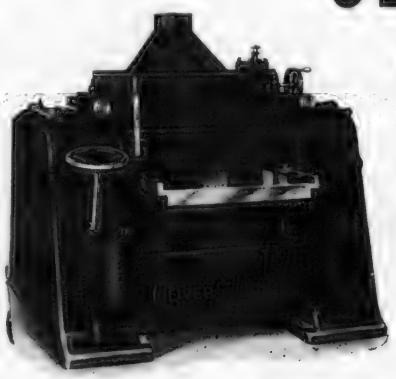
SODIUM SILICATES

Plywood mills have long depended on PQ Silicate of Soda and its worry-free delivery. Tank trucks, tank cars or drums—you name it and it's yours without delay. Silicate of Soda has found its place in water-resistant wood—paper laminates, corrugated board, beater additives and for treating raw and waste waters.

PHILADELPHIA QUARTZ COMPANY OF CALIFORNIA
Berkeley 10, California

Plants: Berkeley—South Gate—Tacoma

Plane it smoother and faster with this "OLIVER"



Newest features cut production costs!

This "Oliver" smoothly planes all woods up to 30″ and 36″ wide, up to 8″ thick. With motor-on-head it handles 60′ a minute. With V-belt drive it handles up to 90′ a minute. One-piece inclined bed is supported by one-piece wedge. One-piece base assures permanent alignment of working parts. Micrometer adjustment aligns bed and cylinder. Fully enclosed feed mechanism. Easy to operate.

Write for Bulletin No. 361.

OLIVER MACHINERY COMPANY

Established 1890 **GRAND RAPIDS 2, MICHIGAN**

A

PLYWOOD INDUSTRY—
Hot Press Loading & Unloading Equipment . Panel Saws . Panel Patching Equipment (Portable & Stationary) . Drier Feed Elevators . Portable Hydraulic Scissors Lifts . Hydraulic Elevating Tables.

B

LUMBER INDUSTRY—
Automatic & Semi Automatic Lumber Stacking Systems . Hydraulic & Electric Gravity Flow Elevators . Planer Feed Elevators . Lumber Patching Equipment.

C

HARDBOARD INDUSTRY—
Automatic Loading & Unloading Equipment . Transfer Units . Conveying Systems . Trim Saws.

— American —

HARDBOARD AUTOMATION EQUIPMENT

AUTOMATION as applied to the hardboard and panel products industries should mean continuous automatic production.

For many years American has engineered, manufactured and installed many individual automatic machines for special application in the hardboard and panel products industries.

In addition, these machines have been so interlocked as to make complete automatic accumulating and circulating systems designed for continuous automatic production.

Our experience can be of benefit to you as it has been to many of our satisfied customers.

We welcome the opportunity to survey your requirements, whether they be manual, mechanical or automatic.

Call on us for assistance from the smallest pilot operation to the largest producing plant.

2119 PACIFIC AVENUE **TACOMA 2, WASHINGTON**

American MANUFACTURING COMPANY INC.

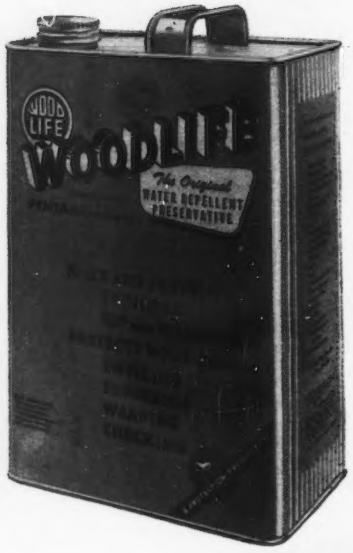
PLYWOOD-HARDBOARD and SAWMILL MACHINERY DESIGNED and MANUFACTURED

DIRECT FACTORY REPRESENTATIVES

IN CANADA:
American Mfg. Co., Ltd.
R. N. Pinton, Manager
Vancouver, B. C.

IN THE SOUTH-EAST:
American Mfg. Co., Inc.
Henry H. Keenan, Manager
Greensboro, No. Carolina

More than just a preservative



WOODLIFE

The Original WATER REPELLENT PRESERVATIVE

CONTAINING **PENTA**chlorophenol

—the quality water repellent preservative.

Here's the finest protection wood can have . . . WOODLIFE—the original *water repellent* wood preservative. Effectively protects against water and moisture absorption, fungus decay, swelling, shrinking, warping, checking, grain raising, termites and insects. WOODLIFE actually exceeds the requirements of the Preservative Minimum Standards of the National Woodwork Manufacturers' Association and meets the specifications set-up by several departments of the Federal Government and Armed Forces. *Here's the finest protection wood can have!*

Send today for the informative folder, "WOOD PRESERVATION WITH WOODLIFE", which gives test data along with suggested specifications

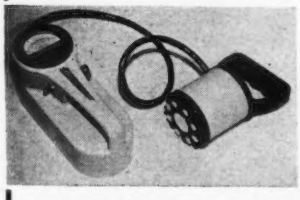
Protection Products
MANUFACTURING COMPANY
Since 1921
Dept. F **Kalamazoo, Michigan**

INDEX TO ADVERTISERS

	Page
Allis–Chalmers Manufacturing Co.	32-A
American Cyanamid Co.	2nd Cover
American Manufacturing Co.	55-A
Behr–Manning Corp.	1-A
Black Brothers Co.	30-A
Borden Co.	16-A
Buss Machine Works	3-A
Chapman Chemical Co.	4-A
Consolidated Baling Machine Co.	50-A
Filer & Stowell Co.	6-A
Fjellman–American, Inc.	4th Cover
Greenlee Bros. & Co.	12-A
Gruendler Crusher & Pulverizer Co.	49-A
Koppers Co., Inc.	28-A
Laucks Laboratories, Inc.	50-A
Masonite Corp.	22-A
Mattison Machine Works	3rd Cover
Merritt–Solem Corp.	18-A
W. F. Meyers Co., Inc.	49-A
Monsanto Chemical Co.	2-A
Moisture Register Co.	56-A
National Starch Products Co.	5-A
Oliver Machinery Co.	54-A
Perkins Glue Co.	10-A
Philadelphia Quartz Co.	54-A
Protection Products Manufacturing Co.	56-A
Radio Receptor Co., Inc.	8-A
W. H. Rambo	51-A
Reichhold Chemicals, Inc.	7-A
Skoog Engineering Co.	52-A
Standard Dry Kiln Co.	51-A
Stetson Ross Machine Co.	20-A
Whitmire Research Labs., Inc. (Mine Safety Appliance Co.)	53-A
Williams Patent Crusher & Pulverizer Co.	53-A
Williams–White & Co.	48-A
Wilco Machine Works	9-A
Wood-Treating Chemicals Co.	51-A

MOISTURE REGISTER

- Insures quality, tells moisture content for best woodworking results.
- Saves you money, helps cut freight costs.
- Protects your purchases, makes sure orders are filled correctly.
- Increases customer goodwill by insuring your deliveries to meet customer requirements.



Moisture Register Model RF4 with push-button electrodes.

Moisture Register instruments test moisture content in wood and wood products down to 0% with guaranteed performance. There's a model for every purpose, both radio frequency and needle types, priced for every budget. New models now available for wood waste and plaster. 10-day free trial offer. No obligation! Write today, outlining your requirements. Ask for information on Moisture Register instruments specially designed for the textile, leather, paper and wood industries.

MOISTURE REGISTER CO.
1510 West Chestnut St. **Alhambra, Calif.**

they like the MATTISON MOULDER at Tomlinson . . . . .

Since 1900 Furniture by Tomlinson has been a quality name from coast to coast. The finest equipment for all phases of production are a *must* . . . naturally they like the Mattison Moulder at Tomlinson.

The Tomlinson operator likes it because it is as easy to set-up, feeds so easy and produces so few rejects . . .

The Tomlinson foreman likes it because he gets production when he wants it and as he wants it—*good* . . .

The Tomlinson superintendent likes it because it produces high quality quickly and easily and his production schedules are consistently met . . .

The Tomlinson cost department likes it because it produces high quality work at low cost . . .

The Tomlinson management likes it because work comes through uniformly accurate, and proper fitting — a necessity in producing high quality bedroom, living room and dining room furniture by Tomlinson.

Yes – makers of Furniture by Tomlinson like the Mattison Moulder — and *you* will like it, too!

MATTISON MACHINE WORKS

ROCKFORD · ILLINOIS

FJELLMAN

makes money for you!

No dead weight in castings—Fjellman presses are all-steel construction . . . minimum yield, great rigidity, light floor loading, low shipping cost, minimum building alterations, quick installation. Bored solid Swedish fire-box carbon steel platens distribute absolutely uniform heat over entire area. Guaranteed less than .003" deflection. *Quick closing . . . automatic, accurate constant pressure.*

ALL FJELLMAN presses available with American equipment

American controls and gauges as well as pumps and motors will be furnished when specified. S.A.E. replacements throughout.

FJELLMAN AMERICAN INC.

Your exact requirements will be met from the wide selection of Fjellman-American hydraulic veneer presses. Up to 24 openings; platens up to 8' x 24'; pressure ranges 80-4000 PSI. Full information with all engineering and installation details, costs and delivery furnished without obligation.

FJELLMAN - AMERICAN, INC.

105 REPUBLIC AVENUE JOLIET, ILLINOIS